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PROMOTION OF THE MECHANIC ARTS.

DECEMBER, 1856.

CIVIL ENGINEERING.

*Description of the Drainage of the Haarlem Mere.**

(Continued from page 297.)

The width of the canal is not every where the same; from the *Schinkel-polder* on the south-east side of the lake to the sluices at *Halfweg* it has the greatest breadth, amounting to 45 met. (147½ ft.), for a good conveyance of the water to the sluices. From *Halfweg* to the *Oude Wetering* on the south side its breadth is 40 met. (131¼ ft.), the remaining part being 38 met. (124½ ft.) in width. At the foot of the enclosure of the bank, at the side of the canal, an enlargement has been made along its whole length, having a breadth of 6 met. (19½ ft.), for a towing-path, which, between the sluices *Halfweg* and the *Spaarne*, has been brought to 11 met. (36 ft.), a provision for the future enlargement of this part of the canal also, if necessary, to a width of 45 met. A second foot-path, having a breadth of 2 metres (6 ft. 2 in.), has been constructed for giving a greater capacity to the canal when (as in the winter) the waters rise to a high level, offering, at the same time, a ready means of increasing its capacity if hereafter found necessary. The top of the embankment has a height of 1·307 met. (4 ft. 3 in.) above the datum line, which we will notice hereafter. The breadth at bottom is generally 11 met. (36 ft.), at some points more, while its breadth at top, on the whole length, is 4 met. (13 ft.) Its slope on the side of the mere is five times the height: on the side of the canal, twice the height. A section of the canal and embankment is given (see Fig. 2), showing its configuration where it intersects the low lands of the *Schinkel-polder*, thus necessitating a second embankment on the other side of the canal to isolate it there-

* From the Lond. Artizan, July, 1856.

from. At the time of the construction of the embankment, its height was considerably more than the intended one described above, this greater height being an allowance for the contracting of the materials of which

Fig. 2.

its body was formed, a great deal of which was peat, a material, however, which, after being thoroughly dried, is very compact and impervious. At some points many and great difficulties had to be surmounted while constructing the embankment, arising from the softness of the soil, which was accomplished by the use of fascines and layers of sand, but which raised the cost of this part to 52·58 fl. per running met. (= £4 per yard), this being the highest price which was paid for the canal and embankment. Where they were not constructed through the water, the price varied from 21 to 32 fl. per met. (from £1 12s. to £2 8s. 8d. per yard). The construction of the embankment through the water was performed by the lowering of layers formed by fascines, until a good basis had been formed, on which was laid the body of the embankment. On the other side, a second dam had to be constructed, after which the water was removed from the enclosed space, for the formation of the canal; the cost of these works being on an average 126 fl. per met. (£9 12s. per yard). Great difficulties arose at the construction of the canal and embankment on the south-east side, where the existing meres and pools had to be isolated from the lake. The small strip separating these waters, which seemed to be land, was not really so, but consisted of water-plants, so tightly interwoven, that they formed a layer, floating on the water, and of such a stability that a man could walk on it with perfect security. This phenomenon is met with at different places where a fenny bottom is covered by stagnant water, which greatly promotes the growth of aquatic plants, which originate at the bottom and afterwards float to the surface, where they collect and form the floating land as described. It was not an easy task to construct an embankment on such a foundation, but it was happily accomplished in the following manner:—At the place where the canal had to be made, the floating land was cut away, and the stuff thus got out was thrown up at the sides upon the line where the embankment had to be formed; thus, by continuously bringing upon it new layers, the floating land under the now partly-formed bank was sunk by the superincumbent weight, which was augmented by the materials resulting from the dredging of the bottom of the canal, until the first layer reached the bottom, at the depth of no less than about 3·5 met. (11½ ft.) beneath the surface. On this basis the body of the embankment was constructed, which has proved to be very compact and firm. The canal has a length of 59·596 kilom. (37 miles), and has cost, with the embankment, 1,938,328 fl. (£161,528), or 32·52 fl. per met. (£2 9s. 6d. per yard). The embankment, though at first not quite impermeable, which is seldom the case with such works, when newly laid, showed no alarming symptoms of leakage, and has since stood very well. At some points new materials had to be brought upon it, to compensate for the

lowering and contracting of the top, by the drying up of the materials of which it was formed, and many repairs had to be undertaken, in consequence of damages by storms before the finishing of the drainage. In 1843, the enclosure of the mere was finished, save the points which had to be held open for the navigation, and which were not to be closed before the commencement of the drainage, which was considerably delayed by many circumstances, the description of which, however, has little interest for the reader.

In the meanwhile it was taken into consideration what was the kind of engine and machinery for raising the water to be adapted, it having previously been determined that steam was preferable to the inconstant and variable force of the wind. The determining of this point was confided to the engineer, Byerinck, and the professors Simons and Lipkens, of which the last named is since deceased. The conclusions of their report were chiefly as stated hereafter.

The first point to be kept in view was that whatever description of engines were employed, they were not only to be so constructed as to be suitable to empty the waters from the mere, but that afterwards they also might keep it dry. Once being dry, the same engines which had served to empty the lake, and therefore had been continuously at work, had but to be set in action at intervals for the discharging of the superfluous water resulting by rains and filtration, so that the force required for this purpose being known, the engines could be projected according to this basis, while they should be powerful enough to drain the lake by a continuous action. The quantity of water to be carried off amounted to 724,000,000 cubic met. (about the same number of tons), to which were to be added 36,000,000 cubic met. yearly during the drainage, and 54,000,000 afterwards. But to ensure a good drainage afterwards, the most unfavorable circumstances had to be taken into consideration, that is, very wet months; the greatest quantity of water to be raised during one month amounted to 36,200,000 cubic met., which calculations were based on the results of observations continued during 91 years.

According to experiments, the largest wind-mills used raise in no case more water than 60 cubic met. to the height of 1 met. per minute. Experience has shown that such mills work with full force during no more than sixty days of twenty-four hours out of the 365 days of the year, so that such a mill can raise yearly about 5,184,000 cubic met. of water, or say, 6,000,000 to the height of 1 met., or 19,374,000 tons of water to the height of a foot. It is assumed in practice, that such a mill (the number being in due proportion to the surface of the land to be kept dry) must work thirty days yearly for thoroughly draining such low lands, so that the duty of such a mill may be reckoned at 3,000,000 cubic met. of water raised 1 met. yearly. These calculations are, perhaps, too much in favor of the wind-mills, it being the reporter's wish not to exaggerate the advantages of the use of steam power.

The height to which the water was to be raised after the drainage of the lake, was 5 met. (16 ft. 5 in.), so that two rows of mills were required, the highest of which was to receive the water raised by the lower ones, and in each row were required 60 mills; or while there existed

examples of land kept dry by a slightly less number, 57 mills were assumed for each row, or a total of 114.

A horse-power being equal to 75 kilos. raised one met. per second,* or 4·5 cubic met. water raised to the same height per minute, the useful effect of a horse-power actuating a pump may be fairly taken at 4 cubic met. raised 1 met. per minute, while if actuating scoop-wheels, or archimedean screws, it will amount to 3·5 cubic met. Deducting a day monthly for stopping, the steam engines, capable of discharging the quantity of water monthly under the most unfavorable circumstances when moving pumps, should be of 1084 H. P., while with the use of scoop-wheels or screws, 1238 H. P. would be required, or, in round numbers, say 1200.

It was, therefore, recommended to have single-acting engines, working pumps divided at three points of the lake; each engine of 360 H. P., or when it should be found necessary to use less powerful engines, six engines of 180 H. P. each, which could be worked at 200 H. P.

If the use of wheels or screws should be preferred, two rows of engines were to be erected, each row having three engines of at least 200 H. P., so that a total of six engines would have to be constructed, of a collective power of 1200 horses—these engines, however, to be double-acting.

Using wind-mills, the highest row, of fifty-seven mills, should be capable of emptying the half quantity in 14·2 months, or say fifteen months, after which time the lowest row could be erected. The second half having to be raised so much higher, could not be discharged in less than at least double the time—say thirty-three months—so that, if all the circumstances were highly favorable, the mere could be drained within a space of four years. The price of each wind-mill was reckoned at 26,000 fl (£2166), and the expense for attendance and repairs, 750 fl. (£62 10s.), so that the total expense for the 114 mills, during four years, including the interest on capital, would amount to rather more than 3,700,000 fl. (£30,000).

If single-acting steam engines and pumps were to be used, taking but 250 working days annually, no less than 115 days being allowed for stopping, for repairs, and other causes, they could drain the mere in ten months and a half—say fourteen months—as a pump, in common with all water-raising machines, does not produce the same useful effect at the different heights to which the water is raised. It was calculated that the drainage in this manner would necessitate an outlay of 1,200,000 fl. (£100,000).

In the case of steam engines actuating scoops or screws, the upper half of the water could be discharged by three engines, of a collective power of 600 horses in 6·1—say 8 months—when the other three engines had to be erected, and the remaining half—for the same cause as in the case of wind-mills—would require 12·7—say 16 months—so that the drainage in this case would be accomplished within two years, at an expense of 1,700,000 fl. (£142,000).

The yearly expenses for keeping the lands dry after the drainage, would

* This calculation of a horse-power, generally assumed in the decimal system, corresponds nearly with the one commonly used in England, it being reduced to English weights and measures, 32,549 lbs. raised 1 ft. per minute.

amount, in the first case, to 74,200 fl. (£6200), in the second to 54,000 fl. (£4500), and in the third case to 73,000 fl. (£6000).

The drainage by pumps, worked by single-acting steam-engines, offered an advantage in the expense of 2,500,000 fl. (£200,000), in favor of this system over that of drainage by wind-mills, while the difference of the yearly cost afterwards amounted to no less than 20,200 fl. (£1600).

It having been decided that the lake should be drained by single-acting engines, having suction-pumps, according to the results of the calculations mentioned, the general arrangements and details of the engine and pumps remained to be determined—a matter of no common interest.

The sub-Committee of the Commission which had made the above report, prepared a plan and made different experiments, to devise the best construction of buckets and foot-valves for pumps of the great dimensions required. At the same time, the English engineers, Messrs. Gibbs and Dean, who, as early as the year 1839, had presented to the government a plan of engines for draining the lake—which was then not approved of—offered a new plan of Cornish engines, applied to plunger-pumps, for the same purpose. In consequence thereof, it was resolved to charge the said engineers with the formation of a new plan, of which the principal points were prescribed by the sub-Committee, and accordingly the drawings were made. Eleven pumps were placed in the circumference of a circle, each pump being worked by a lever, and the opposite ends of these levers converging to the centre of the circle, where the steam cylinder was placed. On the top of the piston-rod a heavy weight was attached, which could be raised by the steam entering the cylinder from below, while the pump-buckets descended by their own weight. The piston having reached the top of the cylinder, the equilibrium valve had to be opened, allowing the weight to descend, carrying with it the eleven levers, which, at their other ends, raised the buckets. To take as much advantage as possible of the expansion, and diminishing, at the same time, the dead weight, it was proposed to adopt two cylinders, connecting their pistons in the manner suggested by Mr. Simms, but instead of placing them one above the other, which would have required a considerable height, they were to be placed *one within* the other, so that the outer cylinder was to be furnished with an annular piston, moving simultaneously with the solid piston of the inner cylinder. Working with eleven pumps, at each stroke 66 cubic met. (nearly 66 tons,) of water would be raised, which, for ten strokes per minute, would give 660 cubic met., or 950,400 cubic met. per day of twenty-four hours. The number of eleven pumps was adopted for the purpose of being able to work with a less number of pumps when the height to which the water had to be raised should increase, so that the working pumps would always balance each other; and that, finally, only three pumps should be worked, making, one with the other, an angle of 120°, and which, with ten strokes per minute, would raise 180 cubic met. per minute. After the drainage of the lake this quantity would have to be raised per minute to a height of about 5 met., corresponding with 900 cubic met. raised 1 met., corresponding with a power of 200 horses. If the double cylinder engine should realize the expectations, it would give out a power of 350 to 400 horses, so that, in such a case, six pumps

would be moved—three on each side, balancing each other. It was, however, expected, and amply confirmed by the results, that more pumps, moved with a less velocity, would be preferable. This plan being adopted, the engine and pumps were contracted for by Messrs. Fox & Co., and Harvey & Co., in Cornwall, while the eleven pump-levers and the boilers were contracted for by Messrs. Paul van Vlissingen and Dudok van Heel, at Amsterdam. In the meanwhile the building was commenced on the south side of the mere, near the *Kager* Mere, on the spot marked on the map *the Leeghwater*—this being the name to be given to the first engine to be erected for executing the great work, of which two centuries ago, the idea was conceived and the plan made, by the enterprising man bearing the same name. Fig. 3 is a general plan (to a small scale), and Fig. 4 is a sectional elevation of engine-house, engine*, and

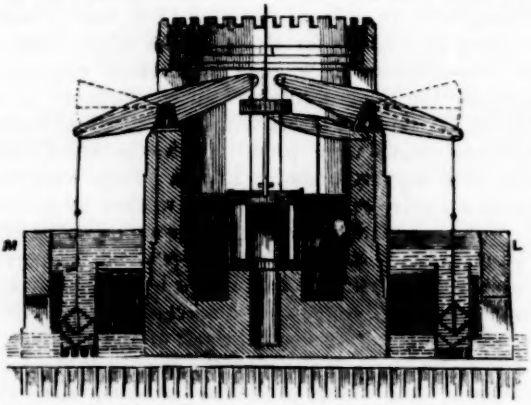


Fig. 3.—Sectional Elevation of Engine-house and Pumps.

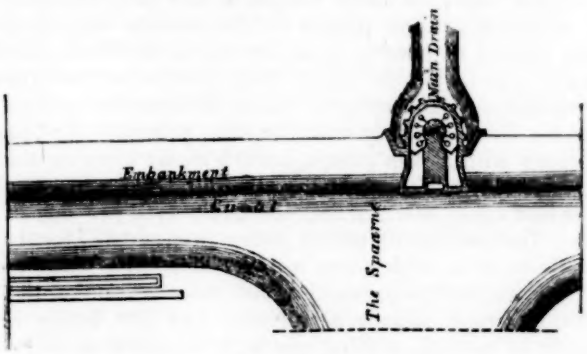


Fig. 4.—Plan.

pumps; the building consists of a round tower, in the centre of which the cylinder is placed, while it is surrounded, at some distance, by a

* The sketch represents not *the Leeghwater*, but one of the two engines erected afterwards, with the different modifications which were considered necessary, of which the principal was the substituting eight pumps for the eleven, with an equal collective capacity.

strong wall, with arched apertures, to give access to the water. The foundation for this building was constructed by means of a heavy dam, and deepened out to about 7 met. (23 ft.) beneath the surface. No less than 1000 piles, of a length of 12 met., had to be driven in the bottom, while the tower had to be supported upon 400 oak piles. On the top of these piles a strong wooden platform was laid, on which the brick walls were erected, those of the tower having a thickness of 3·08 met. (9 ft. 10 in.) at the footing, while the thickness of the surrounding wall is 1·54 met. (5 ft. 2 in). The inside diameter of the tower, at the level of the floor, is 9·25 met. (30 ft. 4 in.), while the space between the outer wall of the tower and the inside of the surrounding wall measures 5·80 met. (19 ft).

The difference of the level of the canal, into which the water is discharged, amounts to 0·60 met. (nearly 2 ft.), the mean of which two levels we will take as the datum line for taking the measures of heights, and which we will call the mean level. (M.L.) In the space between the building and the surrounding wall, which rises to 1 met. (3 ft. 3 in.) above M.L., is laid a strong flooring of oak, at 1·33 met. (4 ft. 4 in.) below M.L. The pumps rest on bottom pieces, being open for the passage of the water; these bottom pieces, being set upon the wooden platform, which lies at a depth of 5·66 met. (18 ft. 7 in.) beneath M.L., while their heads pass through the flooring to a height of 0·78 met. (31 in.) below M.L., or 0·48 (19 in.) beneath the lowest level to which the water has to be raised. In the space between the building and the wall, above the floor, the water is received, and discharged on either side of the boiler-house by the sluice-gates corresponding with the canal, from which it is conveyed to the sea, at the different points, before indicated. The pumps of the *Leeghwater*, of which there are eleven, have a diameter of 1·60 met. (63 in.), while those of the two other engines, being eight in number for each engine, have a diameter of 1·85 met. (73 in.), the length of stroke of all the pumps being 3 met. (10 ft). The buckets and foot-valves may be described as butterfly-valves, being so constructed as to offer the greatest possible area for the passage of the water, for which purpose the valve on opening, rises with its hinges about 4 centim. (1½ in.), which, to a great extent, promotes, by the flow of water, the cleaning of the valves from the mud which may collect there. The valves are constructed of plate-iron, 26 millim. (1 in.) in thickness, and rest upon beds of wood lined with leather. Experiments which were made with the aim of ascertaining the loss by leakage of the valves, have shown that this loss amounted to no more than $\frac{1}{10}$th of the whole quantity. The pump-buckets are moved by the great levers, having a length from centre to centre of 10 met. (32 ft. 10 in.), and weighing each 10,000 kilos. (10 tons), and are connected thereto by rods, to the lower end of which are attached chains, which connect them with the buckets. The chain is for the purpose of preventing a shock to the bucket-valves when the steam-piston should happen to rise with too great a velocity, and, by the flexible chains, the buckets will descend by their own weight, without being affected by the velocity of the piston. The other ends of the levers are connected to the great cap surmounting the piston-rods by suitable straps. This cap, having a diameter of 2·8

met. (9 ft. 2 in.), is divided into eight chambers, containing the dead weight, amounting with the cap, to about 85,000 kilos. (85 tons). This cap is guided by the central piston-rod, which is lengthened above the cap, and moves through a stuffing-box in the beam by four guide-rods, two on each side of the cylinder. The engine has, as is stated above, two cylinders, one within the other, the outer being provided with an annular piston, which has a diameter of 3·66 met. (12 ft. ¼ in.), while the inner cylinder has a diameter of 2·14 met. (84¼ in.), its thickness being 44 millim. (1¾ in.), so that their respective areas are as 1 : 2·9; their stroke is the same as that of the pumps—viz: 3 met. (10 ft). The piston-rod of the central piston has a diameter of 30·5 centim. (12 in.), while the four piston-rods of the annular pistons have each 11·5 centim. (4½ in.) diameter. These four piston-rods are connected at their tops to the great cap, which, accordingly, by its ascending and descending, determines the motion of the pump-buckets. The manner in which the steam works in the cylinders is as follows:—The steam is admitted on the up-stroke, and the piston having reached the top, the equilibrium valve is opened, whereby the steam is allowed to enter at the top of the cylinder, diffusing itself not only at the top of the inner, but, at the same time, of the outer cylinder, while the upper edge of the inner cylinder does not reach to the under side of its cover, but leaves a space of 1½ in. The steam pressure, above and below the piston of the inner cylinder, being thus in equilibrium, the piston descends by the expanding steam acting on the annular piston, in this manner assisting the descent of the dead weight, which is reduced thereby in the same proportion. But the piston, which must remain stationary during some few seconds, to allow the valves of the pumps to close without a shock, should redescend before the opening of the equilibrium valves, the expanded steam in the small cylinder not having force enough to hold up the weight. To meet this difficulty a particular contrivance has been applied, which, in its general arrangement, may be described as a cataract. It consists of two plunger-pumps, having a diameter of 23 centim. (9 in.), attached to the extremities of the cap. When the piston ascends, these pumps are filled with water from pipes, having a height of 10 met. (32 ft. 10 in.), with which they communicate by valve-chests containing only suction-valves. At the top of these chests are pipes, which unite in a single valve-chest containing a valve, which can be lifted by a falling weight actuated by a cataract, which, at the same time, raises the equilibrium valve. When the piston has reached the top of the cylinder it remains stationary, on account of the plungers not being able to return until, by the action of the cataract, the valve is lifted and the water returns to the pipes. At the same time, the equilibrium valve is opened, allowing the steam to act upon the top of the pistons. During the short period of rest, the pump-buckets reach the bottoms of their respective pumps, while the valves are closed gradually. At first sight it may seem that the pumps to uphold the weight are superfluous, and that it would have been possible to omit them, by not expanding the steam in the inner cylinder, and proportioning the capacities of both cylinders in such a manner that the final expansion should take place in the outer cylinder. But it must be remembered that in such a case the difference between

the initial and final pressure at the descending stroke would have been far too great, so that the piston would have descended with a velocity which would have been dangerous for the whole engine, and especially for the pumps, even so that with the actual arrangement a throttle-valve is placed in the equilibrium pipe to moderate the descent. The pressure at the commencement of the descending stroke is about 19 lbs. per sq. in. (the habitual working pressure being three atmospheres), and the pressure at the end of the stroke is 8 lbs. per sq. in., giving a difference of 11 lbs.; while, with another proportion between the capacities of the cylinders, the end pressure remaining the same, the initial pressure would have been 30 lbs., giving a difference of 22 lbs., or double that of the actual pressure.

The engine has two air-pumps, one of which is indicated in the sketch, each being actuated by a lever which is connected to the cap; they have a diameter of 1·02 met. (40 in.), and 1·52 met. (5 ft.) stroke. The *Leeghwater* has five boilers, but the two latter engines erected have each six of the same dimensions; the sixth boiler being added, not from any want of steam, but so as to have a greater boiler-room, whereby the advantage of a slow combustion could be obtained. The boilers are contained in the boiler-house, indicated in the plan, Fig. 4, and are cylindrical, with internal flues. They have a diameter of 1·82 met. (6 ft.), the diameter of the flues being 1·22 met. (4 ft.), and their length 9·15 met. (30 ft). A cylindrical steam chamber, having a length of 12·80 met. (42 ft.), and a diameter of 1·37 met. (4 ft. 6 in.), is placed transversely over the boilers, communicating with each of them by a particular stop-valve. The steam pipe to the cylinder has a diameter of 0·61 met. (2 ft). The contract price for the building was 161,000 fl. (£13,800), while the engine and boilers have required an expense of 207,050 fl. (£17,254). Experiments conducted by the sub-Committee to test the power and economy of the engine, show that the engine is capable of giving out a net power of 500 horses, and even more. At the most favorable experiment the consumption of fuel was 1·17 kilos. (2·6 lbs.) per H. P. per hour, and the duty 70,000,000 lbs. raised one foot high by the consumption of 94 lbs. of coal. In many of the engines in Cornwall the highest duty is considerably more, even as high as 100,000,000 lbs.; but it must not be overlooked that the motion imparted to the water requires a certain force, which remains constant at all heights. Accordingly this force, while it bears but a very small proportion to the total power to be expended when the water has to be raised to a very great height, as is the case in mines, bears a far greater proportion to the force required when the water has to be raised to no more than 5 met. (16½ ft.), and may considerably affect the economy of the engine. It is most difficult to estimate the value of this force, no experiments having been made which can be fully relied upon. For testing the power of the engine an experiment was made with the eleven pumps, raising the water to a height of 5 met (16½ ft.), that being the maximum height to which the water was to be lifted after the drainage. The number of strokes at that time being eight, the net power—deducting $\frac{1}{10}$th for the loss by leakage—was 528 H. P. This number of strokes with such a load, and even with a less height, was considered unsafe, and was not required, so that generally the number of strokes has been from five to seven.

In the month of November, 1845, the *Leeghwater* was ready, and the drainage might have been commenced if no great difficulties had arisen between the direction of the district *Rhynland* and the commission about the height to which the canal (being part of the *boezem* of the said district) would have to be raised by the action of the engines. This question was not settled until the latter part of the year 1847, at the commencement of the winter, when the *boezem* was at a high level, so that had pumping been commenced at that time the water pumped out during the winter would have been discharged, naturally, in the spring, when the *boezem* stands always on a lower level.

(To be Continued.)

AMERICAN PATENTS.

List of American Patents which issued from October 7th, to October 28th, 1856, (inclusive,) with Exemplifications.

OCTOBER 7.

1. For an *Improved Ring-bolt for Ships' and Boats' Tackle;* Hubbard Bigelow and Mortimer M. Camp, New Haven, Connecticut.

Claim.—"The tongue, the hold-fast, and the levers, as arranged in relation to the body."

2. For an *Improvement in Soda Fountains;* John F. Boynton, Syracuse, New York.

Claim.—"The arrangement of the plunger and vessel, whereby the acid may be measured and delivered to the other ingredients in determinate quantities Also, the spring drip valve, or its equivalent, whereby the vessel is entirely emptied of acid after a charge is worked off."

3. For an *Improvement in Bumper Arrangement for Uncoupling Railroad Cars;* William O. George, Richmond, Virginia.

Claim.—"The arrangement of sliding rods, running longitudinally beneath the platforms of railroad cars, so connected with the coupling pins of different cars, that they may be simultaneously detached from each other by simple contact of the sliding rods, at the same time that the engineer or conductor is enabled to disconnect one or more of the cars if desired."

4. For an *Improvement in Vegetable Cutters;* George W. Childs, Liberty, Penna.

Claim.—"The vibrating cross knives."

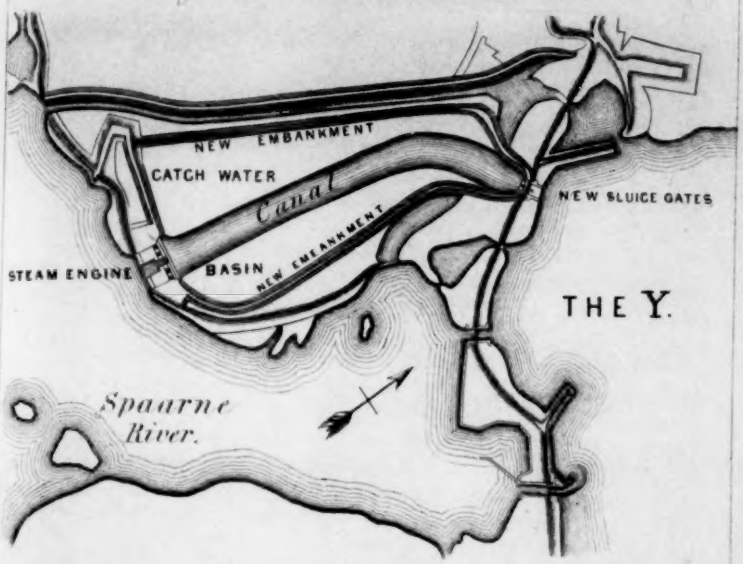
5. For an *Improvement in Smut Mills;* Joel W. Cormack, Quincy, Illinois.

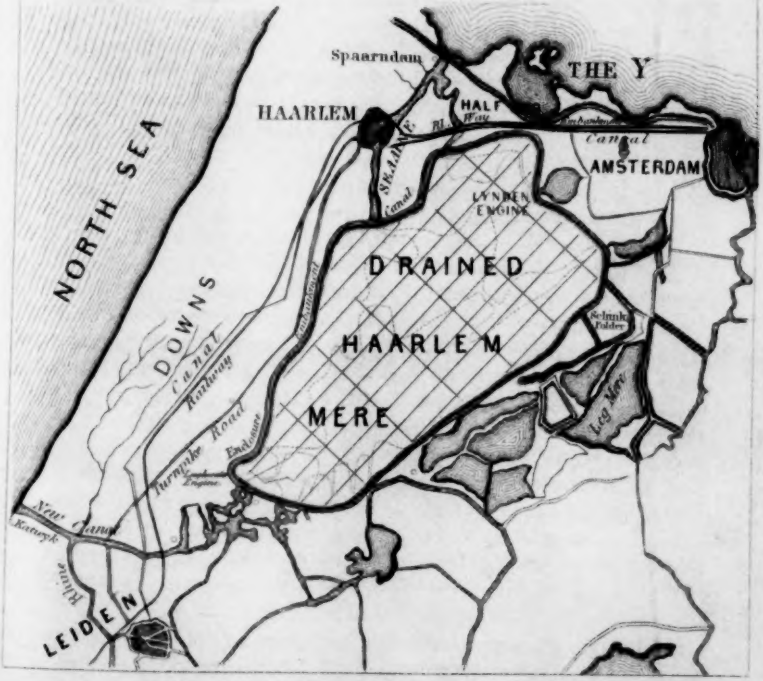
Claim.—"The combination of the cones and creepers, arranged and operating in connexion with the flanched rims, attached to the cones."

6. For an *Improved Machine for Folding Paper;* Cyrus Chambers, Jr., Kennett Square, Pennsylvania.

Claim.—"1st, Causing a folding machine to make the crease for the fold in paper, or other substances, so that any number of sheets fed successively to the said machine, may be folded to correspond to the printing, or other impressions made thereon by means of the points or register pins, or their equivalents, and the holes by which the sheet was registered upon the press; or the holes or marks made in the sheet for any other purpose. The said pins being adapted to the said holes or marks, and the sheet or substance to be folded, placed upon the said pins by using the said holes or marks for that purpose. 2d, The manner of adjusting the register pins, and their peculiar movement. 3d, Supplying the straight edge or blade, or its equivalent (which forces the paper into recesses or between converging surfaces, or their equivalents), with fine points. 4th, The bars and the stops, independent of, and in combination with, each other, as well as

Drainage of the Haarlem Mere.





the bars, or the stops, separately or combined, in combination with the endless belts. 5th, Arranging the rollers, which make the second fold below the rollers; which make the first fold, and the rollers; which make the third fold below; and in like manner any number of rollers, so that the substance to be folded may be forced downwards between each pair, thereby enabling a single series of endless belts, or their equivalents, to conduct it from one pair of rollers, and present it for the action of the next. 6th, The fly, in combination with the endless belts, and the mode of making the support of the said fly adjustable; also, the manner of moving the said endless belt. 7th, Arranging a single series of endless belts, so that paper, or other substances, may be conducted by them horizontally from a pair of rollers when passing downwards between them. 8th, Gearing the rollers in such manner as to decrease the speed of the periphery of each successive pair, in the proportion specified. 9th, Controlling the first blade or plate of folding machines, by a treadle or other means."

7. For an *Improvement in Harvesters;* William Dripps, Coatesville, Pennsylvania.

Claim.—"Giving to the cutters of a harvesting machine, a traveling and a rotating motion at the same time."

8. For an *Improvement in the Construction of Hide Frames in Tan Vats;* Elias A. Eliason, Georgetown, D. C.

Claim.—"Arranging a series of ranges of horizontal slats in a false vat or frame upon which the hides are placed, one upon every range, whereby the whole may be simultaneously raised out of the liquor vat (without pumping off the liquor). Also, the axial cross ties, when connected with the frame, in combination with the hooked rods and shaft, whereby the frame or false vat may be revolved or reversed."

9. For an *Improvement in Buoys;* William M. Ellis, Washington, D. C.

Claim.—"1st, The method of mooring buoys, beacons, and floating bodies, by having their cables attached to said bodies, in the line of their calculated centre of tidal pressure. 2d, The method of connecting the forked or V link or shackle to the said buoy, or floating body, by means of a trunnion bolt passing through a metallic tube or pipe, properly set and secured within the said body."

10. For an *Improvement in Hose Coupling;* L. M. Fevry, Assignor to James T. Ames, Chicopee, Massachusetts.

Claim.—"The combination and the application of the various devices for the purpose of coupling firemen's hose."

11. For an *Improvement in Machines for Mixing Mortar;* Benjamin F. Field, Beloit, Wisconsin.

Claim.—"The use of a revolving box of a cylindrical or other form, made to roll upon the ground for the purposes of mixing the mortar by the action of the cross-rods, whilst at the same time it serves to carry the material from place to place, in combination with the method for discharging the mortar from the revolving box."

12. For an *Improved Fly-Trap;* George Gilbert, Westville, Connecticut.

Claim.—"The combination of the revolving cylinder with the screens or wire work."

13. For an *Improvement in Attaching Scythes to Snaths;* David A. Goodnow, Baldwinville, Massachusetts.

Claim.—"The screw and dog, in combination with projection."

14. For an *Improved Arrangement of Elastic Plate-Paddles for Steam Vessels;* Auguste Jouan, San Francisco, California.

Claim.—"The series of vertically divided elastic plate paddles."

15. For an *Improvement in Feeding Pulp to Paper Making Machines;* Israel Kinsey, Hohokus, New Jersey.

Claim.—"Regulating the flow of pulp for making paper, upon the web or cylinder of the paper machine, by the pressure of the pulp in a box receiving its supply of pulp from the stuff-chest, through the aperture in the trunk, and discharging it through an adjustable aperture below the surface of the pulp in the box; the pressure being regulated and kept uniform by the height of the pulp in the box, which is adjusted and maintained by means of a valve, fitting the aperture operated by a float; the combination of the several parts forming a self-acting regulator for the purpose of making paper of equal thickness."

16. For an *Improved Method of Bending Wood;* Edwin Kilburn, Artemas Kilburn, and Cheney Kilburn, Burlington, Vermont.

Claim.—"The bending of wood by forcing it endwise of its fibres into a mould, which is closed on all its sides, but has an open end, is curved longitudinally in the required form, and has the dimensions of its internal transverse section of the piece of wood, thus causing the wood to be confined in a lateral direction during the bending process, for the purpose of preventing the separation of the fibres."

17. For an *Improved Method of Measuring Fluids while Drawing;* Samuel Krauser, Reading, Pennsylvania.

Claim.—"Severing or separating a given quantity of liquid from a mass or column, by a traveling tube and plunger. Also, the gauge plates, in combination with the valve seat or packing of the plunger fitting thereto, for adjusting the measuring apparatus to the exact quantity to be drawn."

18. For a *Plate-Holder for Photographic Cameras;* William and William H. Lewis, Assignors to Malonzo J. Drummond, City of New York.

Claim.—"Forming the glass or vitrified corners, with a flanch or rim in one solid piece, the said flanch or rim taking the edges of the photographic glass or other plate, and irrespective of the manner in which the said vitrified corners are attached to the frame. Also, the receptacle below the glass or other plate to catch any drippings from said plate."

19. For an *Improvement in Harvesters;* Israel S. Love, Beloit, Wisconsin.

Claim.—"The use of the movable rolling guides, placed between the cutting blades and the sill of the harvesters, whether they be used with a sill made entirely of metal, or partly of wood, with more or less metal attached to the same."

20. For an *Improvement in Machinery for Cleaning Wool;* Andrew W. Putnam, Brooklyn, New York.

Claim.—"The combination of the main picker cylinder, and the open and closed concave, in combination with the burring cylinder. Also, the burring cylinder, in combination with the adjustable burring bar or bars, for stripping the burrs and other foreign substances on the fibres."

21. For an *Improved Sash Lock;* Owen Redmond, Rochester, New York.

Claim.—"The swinging bolt, in combination with the slide and case, so that the gravity of the slide shall shoot the bolts, and maintain it in position."

22. For an *Improvement in Glass or Earthen Truss Pads;* Charles C. Reinhardt, Baltimore, Maryland.

Claim.—"The attachment of metallic backs to the glass faces of truss pads, by a flanch around the edge of the back, slipping within the rim constituting the edge of the glass face piece."

23. For an *Improved Machine for Cuttting Irregular Forms;* Charles Spofford, Amesbury, Massachusetts.

Claim.—"The combination of a vibratory spring presser, with a rotary cutter, stock, and two tables, the said presser being made to operate with respect to the cutter stock, and table, and either guide. Also, the combination of mechanism for moving the vibratory spring presser and its spring towards either of the tables, and locking the shaft to the spring, the same consisting of the arm, the two turning bearers, and the treadle or lever connected to the bearers by pitmen. And, in combination with the mechanism for moving the vibratory presser and its spring, towards either of the tables, and locking the shaft to the spring, the auxiliary treadle applied to the main treadle, and supported by a swinging bar."

24. For an *Improved Machine for Finishing Gas Pipe Fittings;* Caleb C. Walworth, Boston, Massachusetts.

Claim.—"The arrangement and combination of the machines operating in a plane around a common centre, for the purpose of screwing or tapping different ends of gas pipe fittings at the same time, when connected by means of a wrist plate, and slotted connexion, or their equivalents, for the purpose of bringing the taps to their work, and yet permit either of them to advance or recede without interfering with the others."

25. For an *Improvement in Nut Machines;* Wm. E. Ward, Port Chester, New York.

Claim.—"The two punches arranged side by side, and operated for punching the central hole, cutting off the blanks from the bar, and discharging the same, in combination with the two holes or two dies, so that a hole is punched in the bar for another nut during the continued motion of the punch to discharge the nut which was cut off during the previous part of the same motion. Also, in combination with the punching and cutting operation, or either, and with the mandrel, or its equivalent, for entering the central hole of the nut blank, the employment of the spring jaws, or the equivalent thereof, for transferring the nut blank from the die to the mandrel, and there holding it until the mandrel enters the hole. Also, the holding of the nut blanks on the mandrel, in combination with the swages for swaging the faces of the nuts. Also, in combination with the mandrel for holding and turning the nut blanks, the employment of the hammers for hammering or swaging the edges of the nuts. And, finally, the combination of the swages for swaging the faces of the nuts, with the hammers for forging the edges of the nuts, by means of which the metal is thoroughly compacted in all directions and a good finish given the entire blank."

26. For an *Improved Vice;* Caleb C. Walworth, Boston, Massachusetts.

Claim.—"The arrangement of two vices so as to revolve about a common centre, and locking the same in any desired position by means of the lever and notches, or any other suitable device."

27. For an *Improvement in Brick Machines;* George J. Washburn and Ephraim H. Bellows, Worcester, Massachusetts.

Claim.—"The combination of a balanced arm with the weighted reciprocating plunger. Also, the means by which the plunger is locked with, and disconnected from, the cylinder, consisting essentially of the pins and the arms."

28. For an *Improved Bracket for Door Springs;* Alexander J. Walker, City of New York.

Claim.—"Constructing one of the brackets used for attaching such rods with an additional hole for receiving and holding them when in operation, said additional hole bearing such a relation to the first, that by changing the spring from one to the other, greater nicety can be observed when applying it, in regulating the power with which it shall act, and of attaching to said bracket a lever to assist in twisting the spring when applying it. Also, securing said bracket in its place by means of a socket inserted in the door or casing, or any other means substantially the same, that will instantly secure it after it has been applied to the spring, and the necessary power obtained, and will also allow of its being easily removed and re-attached when it is desirable, either to alter or entirely remove the power."

29. For an *Improved Hoop Machine;* William B. Wood, Fitchburgh, Massachusetts.

Claim.—"The peculiar arrangement of the several parts of the machine, for the purpose of splitting the poles and shaving the hoops at one operation."

30. For an *Improvement in Pincers for Lasting Boots and Shoes;* Benj. F. Sturtevant, Skohegan, Maine, Assignor to Elmer Townsend, Boston, Massachusetts.

Claim.—"The instrument for lasting boots."

31. For an *Improvement in Cutting Round Files;* Milton D. Whipple, Charlestown, Assignor to A. B. Ely, Newton, Massachusetts.

Claim.—"1st, Operating upon the blank immediately beyond its point of support. 2d Feeding the blank forward, and rotating upon its axis as the cutting proceeds, when it is operated upon by the vibrating cutters. 3d, The method of operating the cutters by means of the wipers and the springs, whereby the force of the blow is diminished as the size of the blank decreases. 4th, Forming the cutters of circular disks, or of portions thereof."

32. For an *Improvement in Mill Stone Dress;* W. P. Coleman, New Orleans, La.

Claim.—"Forming the master and subordinate furrows of the stones as described, viz: the straight portions of the furrows being tangential with the eye, and with circles concentric therewith, and the curved portions being segments of a circle of equal curvature, or thereabouts, to that of the outer peripheries of the stones, for the purpose of rapidly throwing the grain outwards in the early action of the furrows, and retarding or gathering it in by the after or outer portions thereof."

33. For an *Improvement in Coiled Springs for Railroad Cars;* Carls French, Seymour, Connecticut.

Claim.—"Composing the coiled leaf of two or more leaves, placed the one below the other, said component leaves being welded together at one or both ends thereof."

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34. For an *Arrangement of Means for Regulating the Draft of Steam Boilers;* Pliny E. Chase, Philadelphia, Pennsylvania.

Claim.—"The apparatus when constructed and arranged so that the action of the steam in the boiler, when at or above the maximum pressure desired, will cause the draft through the fire-box to be reversed, and pass down through the fire, and again resume its former course in the opposite direction when the pressure is reduced to the minimum."

35. For an *Improvement in Sticking Pins in Paper;* Lydia Atwood and C. O. Crosby, Administrators of Charles Atwood, dec'd., City of New York.

Claim.—"1st, The vibrating nippers, armed with a knife, or double inclined plane, for separating the pins, turning them from a vertical to a horizontal position. 2d, The straight inclined conductor, when combined with the nippers, with their separating points as carrier. 3d, The lipped driver, for driving the pin along a railway or bed laterally into the groove to be stuck into the paper, when it acts upon the pin before the vibrating nipper lets go its hold. 4th, The lateral driver, or its equivalent, for the purpose of delivering the pin under the spring holder, as a means of controlling the pin, until it is inserted into the paper. 5th. The combination of the sticking driver and its guiding groove, with the vertical crimping bars, when the bars permit the paper to pass over their ends vertically in the process of sticking pins. 6th, The feeding rollers, or their equivalents, for the purpose of holding the paper, and controlling it at such a distance from the guiding rollers, as will allow the paper to pass up and down without moving the spools, while the rollers are in motion. 7th, The rollers and carriages which control the pins and the paper, for the purpose of moving the paper forward intermittently, to space off the rows of pins, and to space the distance between each succeeding pin in the same row, the ends of the paper resting on spools dissected from the machine."

36. For an *Improvement in Guides for Working Button Holes;* Otis Avery, Bethany, Pennsylvania.

Claim.—"The combination of the sliding plate with the revolving tweezers."

37. For an *Improved Canal Bridge;* Balaam G. Anderson, Chillicothe, Ohio.

Claim.—"Constructing the bridge of three parts, the parts being connected by joints to the part, and having their supports provided with rollers which work on curved ways at the bottom of the canal."

38. For an *Improvement in Papering Pins;* Lydia Atwood and C. O. Crosby, Administrators of Charles Atwood, dec'd., City of New York.

Claim.—"Fabricating a new article of manufacture, called diamond pin cushions, by sticking pins in ranks or rows through a staple, or U shaped piece of paper, the heads of the pins projecting sufficiently far to allow the pins to be easily and conveniently withdrawn by the fingers for use. The pins being inserted upon two planes of the paper, with the heads projecting beyond the points a suitable distance to protect the points from being doubled or blunted, all the other portions of the pins being protected by the paper, and sustained by it at a short distance from the heads and points by the paper, making a solid mass of pins set in diamonds with regard to each other, but not in contact, and which usually contains the requisite quantity of pins for an ordinary paper for toilet use in a sma lcompass."

39. For an *Improvement in Excavators;* James Bourbin, San Francisco, California.

Claim.—"The application of any number of shovels required, and working from one centre on the circular principle. Also, the different appliances by which the shovels are directed in their movements."

40. For an *Improved Manure Distributor;* J. W. Barnes, Murfreesboro', N. Carolina.

Claim.—"The hinged side, combined with the hinged bottom."

41. For an *Improvement in Sticking Pins in Paper;* Walker B. Bartram, Waterbury, Connecticut.

Claim.—"1st, The separator or spacer, composed of a series of bars, having a simultaneous movement at right angles or nearly so to the line of pins in the pin feeder, and to the line in which the pins are inserted, and a movement one after the other in a direction parallel or nearly so to the said line. 2d, The construction of the driver, with recesses in its face to receive the heads of the pins, and act in conjunction with the paper after the points of the pins have penetrated it, to serve the purpose of guiding the pins straight and parallel through the paper, thus enabling the holder to be opened to make room for the driver. 3d, The stop, acting in combination with the separator and spacer, to retain the pins behind the separator and spacer, after a number sufficient for one row has been taken from the feeder by the separator and spacer, but to be moved away by the separator and spacer. 4th, The bar, operating in combination with the forceps, to form a second holder below the principal holder, and more perfectly secure the upright and parallel positions of the pins during the commencement of the driving operation."

42. For an *Improved Pump;* William T. Barnes, Buffalo, N. York, and Jacob Barnes, Oakville, Canada West.

Claim.—"The employment of the priming reservoir, or its equivalent, which is connected to the pump, and fills it with water by the action of the pump, which water is held by the supporting box, or its equivalent, and can be discharged to prime the pump by pulling the cord, or its equivalent. 2d, The combination of the levers, with the piston rods, and the connecting rods, and rocking beam."

43. For an *Improvement in Grain Separators;* Joel W. Cormack and F. C. Walker, Quincy, Illinois.

Claim.—"The cylindrical cheat box, into which the air tube enters. Also, the flanches and funnel, or their equivalent, in combination with the tube, for the purpose of creating the spiral or whirlwind blast in a grain separator."

44. For an *Improvement in Axe Polls;* David P. Estep, Pittsburgh, Pennsylvania.

Claim.—"The manufacture of axe polls by compressing one-half only of the axe poll at each operation, between dies or swages of the shape described, projecting from the face of the rolls in which they are set, so that the axe poll can be inserted and withdrawn without coming in contact with the rolls, in combination with the use of the adjustable guide, either attached to the dies or separate therefrom, for the purpose of applying the pressure necessary to form the axe poll, in such a manner as to leave an excess or deficiency of iron in the head of the axe poll, thus securing exact uniformity in the two sides of the axe poll, and enabling axes of various sizes to be made from the same dies by simply adjusting the distance of the rolls and the gauge."

45. For an *Improved Method of Opening and Closing Farm Gates;* Dennis E. Fenn, Talmadge, Ohio.

Claim.—"The cam, with its alternate elevations and depressions, in combination with the arm and double jointed hinge."

46. For an *Improvement in Harvesters;* Carlos W. Glover, Roxbury, Connecticut.

Claim.—"Attaching the finger bar to the guide box, which is fitted over the flanch of the driving wheel, the guide box having the two shafts attached to it, by which motion is communicated to the sickle from the driving wheel, and the bar attached to the finger bar by hinges or joints, and the guide box to the rod."

47. For an *Improved Firemen's Ladder;* Domenico Giambastiani, Washington, D. C.

Claim.—"The combination of the foundation frame, with the detachable single ladder sections."

48. For an *Improvement in Salt Evaporators;* James L. Humphrey, Syracuse, N. Y.

Claim.—"The arrangement of the furnace, the closed evaporating vessel, the flues, the blower, and the chimney, whereby the products of combustion are drawn through the evaporating vessel below the surface of the liquid to produce evaporation by heat, and afterwards driven in the opposite direction over the surface of the liquid to produce further evaporation, and carry off the evaporation to the chimney. Also, the scraper fitted to the flues and pipes which pass through the liquid in the evaporating vessel."

49. For an *Improved Arrangement of Springs for Side Spar Wagons;* M. G. Hubbard, Penn Yan, New York.

Claim.—"The mode of combining the two semi-elliptic springs with the side spars of light wagons, by bringing one above, and the other below the end of said spar."

50. For an *Improvement in Anti-Friction Bushing for Ships' Blocks;* James Kelley, Sag Harbor, New York.

Claim.—"The mode of constructing the bush by riveting the head within the cylinder, and the annular grooves for the reception of the bearing rings of the rollers."

51. For an *Improvement in Ploughs;* Samuel A. Knox, Worcester, Massachusetts.

Claim.—"The form of the working surface of the mould board of ploughs, and composed or combined of the several characteristic features specified."

52. For an *Improvement in Pumps;* Edwin T. Ligon, Richmond, Virginia.

Claim.—"The combination and arrangement of the two induction passages or branches, the valve chambers, their four valves, the receiving and delivering chambers, their four valve openings, provided with a separate valve to each, or one vibrating plate made to operate between them, the piston being provided with an eduction opening or passage, and the whole being arranged and made to operate within a cylindrical case. Also, combining and arranging four valve openings with one vibrating plate, so that it may vibrate between them and opposite sides of it, and cover two of them at the termination of each of its vibrations."

53. For an *Improvement in Escapement Movements for Automatic Fans;* Don J. Mozart, Xenia, Ohio.

Claim.—"In combination with the sectional scape wheel, the banking pin meeting the sections thereof at each vibration."

54. For an *Improved Method of Hanging Reciprocating Saws,* John H. More, West Troy, New York.

Claim.—"The hinged jaws and screws. Also, the finished faces on the jaws of the fixed body of the stirrup, in combination with the hinged jaws."

55. For an *Improvement in Porte-Monnaies;* John L. Mason, Germantown, Penna.

Claim.—"The construction of the whole of the pockets of a porte-monnaie, or other article of similar character, from a single piece of leather by a system of folding."

56. For an *Improvement in Sawing Stone;* John North, Middletown, Connecticut.

Claim.—"The two inclined reciprocating saws connected with one and the same rotating driving shaft, by the oblique connecting rods, each rod having four joints."

57. For an *Improved Adjustable Stirrup for Saw Mill Pitmen;* Samuel C. Norcross, Dixfield, Maine.

Claim.—"The manner of attaching the stirrup to the pitman, whereby its position on the pitman, and consequently the length of the pitman, may be varied for the purpose of altering the position of the saw with respect to the log."

58. For an *Improvement in Bee Hives;* Charles Pawling, New Pittsburgh, Ohio.

Claim.—"The arrangement of the bee entrances, with the moth entrances, and moth receptacles."

59. For an *Improvement in Washing Machines;* Jacob Purkey, York, Pennsylvania.

Claim.—"The reciprocating corrugated or fluted board or rubber, in combination with the rollers, the rollers being attached to the chains."

60. For an *Improvement in the Order of Applying Tan Liquor to Hides;* Samuel W. Pingree, Methuen, Massachusetts.

Claim.—"The use of the catechu and the sumac and alum, with reference to the application of the bark or strong tanning liquor as stated, and so as to produce effects as set forth, when the hide is tanned with hair on it."

61. For an *Improvement in Uterine Supporters;* Wm. Provines, Columbia, Missouri.

Claim.—"The combination of the ball and the valve apparatus."

62. For an *Improvement in Submarine Exploring Armor;* Lodner D. Phillips, Chicago, Illinois.

Claim.—"1st, A submarine armor with which the explorer can be wholly invested,

composed entirely of metal, having free and easily moving jointed limbs, and from within which the explorer may give motion to the armor, and operate the external means. 2d, Connecting with such armor, a collapsible exterior vessel, so united with the interior air chamber as to allow of its being inflated, and buoy up the armor. 3d, Arranging the rods for operating the exernal tongs or nippers within the tubular arms."

63. For an *Improved Machine for Bending Metal Pipe;* James Perkins and Wm. H. Burnet, Newark, New Jersey.

Claim.—"The mandrel, with the traversing roller, or its equivalent, for bending coils of metal pipe, and in combination therewith the furnace."

64. For an *Improvement in Spring Bed Bottoms;* Charles Schroder, City of N. Y.

Claim.—"The arrangement of springs lying horizontally and connected together."

65. For an *Improved Wheelwright's Machine;* John Sitton, Williamston, N. C.

Claim.—"The several devices when combined and operated."

66. For an *Improvement in Finishing Caster Wheels for Furniture;* Philos B. Tyler, Springfield, Massachusetts.

Claim.—"Finishing caster rollers, and like articles made of cast metal, by stamping them in dies, whereby in finishing the die is hardened, and its thickness determined with exactness, insuring the maximum amount of strength with the smallest weight of material."

67. For an *Improvement in Machinery for Forming Hat Bodies;* James S. Taylor, Danbury, Connecticut.

Claim.—"1st, The revolving feed table, in combination with the picker, cone, and exhaust. 2d, The combination of the revolving brush with revolving perforated cone, for the purpose of moistening the fur as it is thrown upon the cone."

68. For an *Improvement in Manufacturing Cylinders for Cotton Gins and Machine Cards;* John L. Tuttle, City of New York.

Claim.—"The manner of making cylinders for cotton gins, or for carding or cleaning engines, viz: by introducing the fluid metal, which is to unite the teeth to the cylinder, between the cylinders, and through the openings into the space, which unites the whole into one rigid mass, and avoids the danger of irregular flowing of the melted metal."

69. For an *Improvement in Card Teeth for Machine Cases;* John L. Tuttle, City of New York.

Claim.—"The making of card teeth by giving to steel wire the form described, so that when set, and a surface ground on them, the same grinding shall form the sharp points thereon."

70. For an *Improvement in Cotton Gins;* John L. Tuttle, City of New York.

Claim.—"The combined use of the straight edge and roller, for stopping and returning the cotton seeds to the breast of the machine, and allowing the fibre only to pass through."

71. For an *Improvement in Gimlet Handles;* G. H. Talbot, Boston, Massachusetts.

Claim.—"The application within the stock or handle of the gimlet, or other tool or instrument, of arrangement of ratchet or rag wheel gearing, operating so as to enable the tool or instrument to be rotated in another direction at the pleasure of the operator, by turning the handles back and forth in opposite directions, and at the same time pushing it from, or pulling it towards him, the direction of the rotation being varied by the pushing or pulling of the stock or handle."

72. For an *Improved Arrangement of the Thills of Vehicles;* Noah Warlick, Lafayette, Alabama.

Claim.—"The swinging frame composed of bars and braces, adapted to the reception of either thills or pole."

73. For an *Improvement in Railroad Car Coupling;* John C. Ward, Charleston, South Carolina.

Claim.—"The weighted arm, stud, and slide catch, in combination with the partially rotating tumbler, when said tumbler constitutes the securing socket."

74. For an *Improvement in Nail Machines;* Perry A. Wilbur, New Castle, Penna.

Claim.—"The arrangement of the cutting, griping, heading, and delivery apparatus,

with regard to the nail plate feeder, so that the whole may be operated from one cam shaft."

75. For an *Improved Fastening for Gates;* Smith Young, Milton, New York.

Claim.—"The employment of two pivoted spring catches on the post, in combination with a stationary central stop, and two hand levers on the front edge of the gate."

76. For an *Improved Machine for Cleaning Emery Wheels;* Stephen A. Whipple, Shaftsbury, Vt., and Herman Whipple, Port Richmond, New York.

Claim.—"The use of the roller, revolving in contact with water, and the superincumbent wheel."

77. For an *Improved Method of Felling Trees;* Simon Ingersoll, Assignor to the Farmers' and Mechanics' Manufacturing Co., Green Point, New York.

Claim.—"Attaching the saw to the bar, which is connected with the levers and bars, the bar being connected with the spring."

78. For an *Improved Brace for Carriage Springs;* Thomas Dutton, Assignor to J. R. Elvans, Washington, D. C.

Claim.—"The combination of the brace rod with the toggle joint and lever, or any of their equivalents."

79. For a *Hinge for Picture Cases;* Alfred Critchlow, Assignor to A. P. Critchlow & Co., Florence, Massachusetts.

Claim.—"The application of a hinge of a daguerreotype or picture case, moulded of a plastic material, made of a frangible substance or substances, such hinge being made with each of its leaves bent twice, and so applied to the halves of the box, that it may embrace two contiguous sides of such halves, and be independent thereof, and extend or lap over, and be fastened to the top and bottom plates of said box."

80. For an *Improved Chimney Cowl;* Thomas W. Chatfield, Utica, New York.

Claim.—"The use of two inverted funnels, together with the short cylinder."

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81. For an *Improvement in Grain Threshing and Separating Machines;* John Barnes, Mount Morris, New York.

Claim.—"The arrangement in its transverse relationship to the screen, and across the mouth thereof, of the threshing cylinder, on the falling side of the screen when in motion, or mainly on said side, in combination with the introduction of the blast (by branch,) on the rising side of said screen, and between said side and the inner end of the cylinder's throw or action, for the better clearance of the grain from under the cope, and the more easy and effectual separation of the grain as it rises and falls, and is kept free and loose by the lift of the screen."

82. For an *Improvement in Cotton Seed Planters;* Charles R. Belt, Washington, District of Columbia.

Claim.—"Effecting the seed discharge by the opposite reciprocation of the inclined plates, constituting the bottom of the hopper, in combination with the armed rollers, or its equivalent."

83. For an *Improved Apparatus for Cleaning Coulters or Ploughs;* Edmund C. Bills, Jr., Perry, New York.

Claim.—"The employment upon the front of the coulter of an inverted cone, having spiral flanches thereon, self-acting by the upward pressure of the grass to free the coulter."

84. For an *Improvement in Corn Shellers;* William Black, Allegheny City, Penna.

Claim.—"Two or more holes of different sizes, with teeth converging."

85. For a *Reed for Musical Instruments;* J. C. Briggs, Woodbury, Connecticut.

Claim.—"The reed, constructed of a ring or frame, with a vibrator, consisting of a disk or plate suspended by a central stem from a spring, to vibrate within the said ring or frame in right lines perpendicular to the plane of the disk, thereby enabling a column

of air of uniform thickness in all parts to be admitted through the reed, and enabling a uniform vibration to be produced all round the reed."

86. For an *Improvement in Pumps;* John P. Cowing, Seneca Falls, New York.

Claim.—"The auxiliary cylinder placed on top of the pump cylinder, and so arranged as to form a reservoir for oil or water around the stuffing box and piston, and at the same time to support a guide for the piston, which may be turned in any desired position."

87. For an *Improvement in Carriages;* Daniel Freeman, Burford, Canada.

Claim.—"The combination and arrangement of the body supported by, and distributing its weight upon, all four springs, when placed above the axles. Also, the arrangement of the draw bar and brace, by which the former is connected directly with the centre of the fore axle. Also, the arrangement of the fifth wheel or circle, upon the lower of the two front springs. Also, making the head block elastic."

88. For *Bituminous Ground for Photographic Pictures;* Victor M. Griswold, Lancaster, Ohio.

Claim.—"Taking photogenic pictures on paper or other substance, prepared by the above process."

89. For an *Improved Fire Arm;* Alexander Le Mot, New Orleans, La.

Claim.—"1st, The substitution of a shot barrel to the solid cylinder or pin, upon which the revolving cartridge cylinder revolves, constructed upon Colt's or other systems of revolve. 2d, The gun cock with a double hammer."

90. For an *Improvement in Sickles for Harvesters;* Pells Manny, Waddam's Grove, Illinois.

Claim.—"The arrangement at the back of the cutter bar, and for reciprocating operation with it, of a back set of cutters or clearers between the finger and cutter bars, when said teeth are shaped and arranged to cut laterally forwards, alternating in opposite directions through or over the backs of the fingers for joint action with the front cutter or cutters, for the better clearance of the fingers and cutter bar race."

91. For an *Improvement in Harvesters;* Pells Manny, Waddam's Grove, Illinois.

Claim.—"The straining stirrup or brace bar, arranged diagonally beneath the frame, and fitted so as to secure the ready and effectual adjustment of the frame or finger bar portion thereof."

92. For an *Improved Spike Machine;* C. A. McPhetridge, St. Louis, Missouri.

Claim.—"The conducting arms as constructed, when operating in connexion with the means employed for cutting, pointing, heading, and clearing, and the closing guides. Also, the use of the feed rollers, the ratchet wheel, bar, pinion, pawl, in connexion with the wheels and the pin."

93. For an *Improvement in Sizing Hat Bodies;* Joseph McCraken, Brooklyn, N. Y.

Claim.—"The use of the india rubber or other elastic perforated cylindrical roller, for working or sizing hat bodies upon."

94. For an *Improvement in Cotton Gins;* James B. Mell, Riceboro,' Georgia.

Claim.—"The arrangement of two or more sets of ginning rollers in an arch of the radius of the cleaning cylinder, in combination with brushes so arranged as to keep the rollers clean, and the fan for removing the cotton from them as fast as ginned."

95. For an *Improvement in Head Rests for Chairs;* C. A. Mills, Dubuque, Iowa.

Claim.—"The semi-revolving and vertically adjustable supporting rod, said adjustment being effected by means of the spring, with its fork working into the notches of said support, or its equivalent."

96. For an *Improved Screw Machine;* John Moore, Madison, Indiana.

Claim.—"Operating the cutters in the die box, by means of the links, the internal and external plates, in connexion with the bar, the arc, the lever, and set bolts."

97. For an *Improvement in Ships' Capstans;* Charles Perley, City of New York.

Claim.—"Retaining said pinion in place by the overhanging base of the capstan barrel, except at the notches, at which point said pinion can be removed. 2d, Con-

structing the oil receptacle and groove (that contains the sustaining balls,) higher at the outside than the inside, to cause said balls in their motion to lubricate the journal."

98. For an *Improvement in Preparing Clay for Alum Making;* Henry D. Pochin, Salford, England; patented in England, January 30, 1855.

Claim.—"The calcining of china clay, or other aluminous minerals, with the carbonaceous substances, by which the alumina is brought into a condition to be easily acted upon by strong sulphuric and other acids, without adding thereto any substance injurious to the quality of the resulting compound, and the use of aluminous cake obtained in manufacturing the aluminous mordaunts used by calico printers and dyers, and in various other processes used by dyers, and in the preparation of white leather in the process termed tawing; also, in the manufacture of paper as a substitute for alum and the ordinary sulphate of alumina, as well as for the purpose of deodorizing and disinfecting decomposing animal or vegetable matters, and for the preparation of the ordinary sulphate of alumina and alums of commerce."

99. For an *Improvement in Cast Iron Railroad Car Wheels;* John M. Sigourney, Watertown, New York.

Claim.—"The formation of the hub of an iron wheel cast in one piece, viz: recessing the same by means of annular flanches bordering it inside, outside, or both in and outside, when combined with the single plate and braces."

100. For an *Improvement in Cotton Presses;* William F. and Charles J. Provost, Selma, Alabama.

Claim.—"So uniting of the follower nuts and levers, as that when the follower shall arrive at its highest point of elevation, it shall automatically swing out of the way of the filling box to facilitate the placing of the cotton or other material therein."

101. For a *Scale for Instrumental Music;* Abbey S. Smith, Rochester, New York.

Claim.—"An improvement of the established letter organization of the instrumental music scale, by originating and giving tangible form and shape to a character to be called and to denote sharp key A, and another flat key A, and another sharp key B, another flat key B, another sharp key C, and another flat key C, and the same of sharp and flat keys D, E, F, and G; for which characters I claim different specific forms or shapes, of each of the seven adopted musical letters, and different from the adopted shape of the adopted letters, all of which I arrange with other musical characters upon the staff, so that all retain their value, capacity, and position in perfect conformity to the organic law thereof, and the different keys in their definite capacity are in form brought to sight to be read at a glance of the eye by teacher and learner."

102. For an *Improvement in Nail Plate Feeding;* Perry A Wilbur, New Castle, Pa.; ante-dated, October 14, 1856.

Claim.—"Giving to the tubular nail plate feeder, its rising and falling semi-rotating, and forward and backward movements. Also, the lateral adjustability of the nail plate feeder to change the angle at which the nail plate approaches or passes under the cutting die, for the purpose of giving more or less head or point to the nail, whilst said feeder continues to receive its multiple motion."

103. For an *Improved Balance and Fastener for Window Sash;* Walter Worthen, Danville, New Hampshire.

Claim.—"Balancing and fastening window sash by one spring."

104. For an *Improvement in Filing and Setting Saws;* Horace R. Howlett, Assignor to self and A. W. Goodell, City of New York.

Claim.—"The file frame attached to the stock, in connexion with the gauge, guide, and lever, with saw set attached."

105. For a *Machine for Splitting Mackerel;* Sidney S. Turner, Lewiston, Maine, Assignor to self and Elmer Townsend, Boston, Massachusetts.

Claim.—"Combining with the cutting knife, and the movable carriage, a set of centering and holding jaws, or mechanical equivalent therefor. Also, the improvement of making the knife move faster than the carriage, or in other words, combining with the cutting knife and carriage, a mechanism for rotating the cutting or splitting part of the knife at a greater velocity than the carriage may be moved, the same being not only to facilitate the splitting of the fish, but to cause the discharge of it from the carriage.

Also, combining with the holding carriage, the centering jaws, and the splitting knife, a mechanism for operating or opening the centering jaws to allow of the discharge of the fish by the action of the knife. Also, combining with the holding carriage, its centering jaws, and the knife, a mechanism to open the said jaws during the backward movement of the carriage, the same being to prepare said jaws for the reception of a fish."

106. For an *Improvement in Lard Rendering Kettles;* John J. Bate, Brooklyn, N. Y.

Claim.—"The combination of the double steam kettle with the annular chamber, and covering the exterior of said chamber with a non-conductor."

107. For an *Improvement in Combined Table and Bedstead;* Charles Baum, Philadelphia, Pennsylvania.

Claim.—"The frame work composed of the upright posts, longitudinal bars, transverse bars, upper longitudinal bars, in combination with the board, rods, and frame."

108. For an *Improved Method of Bending Wood;* Thomas Blanchard, Boston, Mass.

Claim.—"1st, Subjecting the timber to pressure upon all sides, and continuing the same while it is being transferred from the straight trough to the curved mould. 2d The machine for bending timber, consisting essentially of the following elements, or their equivalents, in combination: 1st, The bending lever; 2d, the device for compressing the timber while it is being bent; 3d, the curved mould in which the pressure is continued, and in which the timber is removed from the machine after the bending operation is completed."

109. For an *Improvement in Washing Machines;* Albert A. Dailey, Wilson, N. Y.

Claim.—"The combination of the fluted cylinder, and concave, with the fluted cylinder."

110. For an *Improvement in Bottle Casters;* Edward Gleason, Dorchester, Mass.

Claim.—"The arrangement of the bottles centrally or thereabouts on or over the pivots of the niched or semi-cylindrical doors, when the latter are arranged for operation in relation to the body of the caster by the central rod or handle. Also, so gearing and connecting the revolving body of the caster with its separately turning doors, and arranging the same with its stationary base, that upon continuing to turn the central rod, after the doors have been opened or closed in the same direction which was required to open and close them, the whole body of the caster is made freely to turn on its base with the doors in the conditions they were set by said turning of the central rod or handle."

111. For an *Improvement in Making India Rubber Hose;* Jacob Henry Howell, Ansonia, Connecticut.

Claim.—"The method of constructing india rubber hose, that is to say, by winding a fillet spirally upon a mandrel, and upon this, winding a second that shall cover or break the line of joining of the first; the said fillets being made to adhere along their cut edges, as well as to each other."

112. For an *Improvement in Machines for Shearing Sheep;* J. V. Jenkins, Jackson, Michigan.

Claim.—"Operating the lever or plate by means of the eccentric upon the shaft, said shaft benig connected by a universal joint to the compensating shaft formed of the tube and rod, the rod being connected to the driving shaft by a universal joint."

113. For an *Improvement in Washing Machines;* James M. Kern, Morgantown, Virginia.

Claim.—"The hollow slotted face presser, in combination with the cloth covering thereof."

114. For an *Improvement in Processes for Silvering Mirrors;* Tony Petitjean, Tottenham Court Road, England.

Claim.—"The employment of tartaric acid with ammoniacal nitrate of silver, for the silvering of glass."

115. For an *Improvement in Rosin Soaps;* Augustus Pfaltz, Saxonville, Mass.

Claim.—"The mode of producing a solid soap from rosin, viz: by the use of an excess of soda or carbonate of soda, so as to form alkaline salts with the pinic and sylvic acids, which compounds are rendered nearly anhydrous."

116. For an *Improvement in Cooking Stoves;* Samuel Pierce, Troy, New York.

Claim.—"The flanches or slats. Also, the method of constructing the ash pit and lower oven bottom plate in one piece, with holes for the passage of air, for the purpose of communicating a greater degree of caloric to the air in the air chamber surrounding the oven. Also, the employment of the dumb flue lying within the upper fire flue, and forming part of this lower plate, and communicating with the elevated oven by a passage opening into its bottom."

117. For an *Improvement in the Process of Coating Metals with Metals;* Joseph Poleux, City of New York.

Claim.—"The employment of muriatic, nitric, or sulphuric acid of the ordinary degrees of concentration in commerce, viz: muriatic of 18° of Baume; nitric 38° do., and sulphuric 66° do., without diluting them, embracing the solution of spelter in the cleansing acid, and passing the cleansed articles directly into the metallic bath without any intermediate treatment whatever."

118. For an *Improvement in Capstans for Steamboats;* John Schaffer, Manchester, Pennsylvania.

Claim.—"The drum on the shaft of the capstan, as arranged, the capstan being steam driven by geared shafting connecting it with the 'little nigger,' and the whole being combined and made operative through the pulley."

119. For an *Improvement in Seed Planters;* Joseph H. Shireman, East Berlin, Pa.

Claim.—"The slide and clearers, in combination with the stirrer."

120. For an *Improvement in Stove Blacking;* William Thomas, Jr., Hingham, Mass.

Claim.—"The compound to be used for coating stoves and metallic surfaces, to impart to them a very durable polish, and to protect them more effectually from rust."

121. For an *Improvement in Devices for Putting up Caustic Alkalies;* George Thompson, East Tarentum, Pennsylvania.

Claim.—"The mode of protecting small packages of caustic soda or potash from the action of the atmosphere."

122. For an *Improvement in Washing Machines;* Charles N. Tyler, Assignor to Henry Pardin, Washington, D. C.

Claim.—"1st, Suspending the shaft to the cross beam, in such a manner as to be free to turn on its axis for the purpose of oscillating the disk to wash the clothes, and at the same time be capable of vibrating back and forth as the lever is raised or lowered, for the purpose of throwing the disk into or out of the tub. 2d, The sliding disk, in combination with the slotted shaft and adjustable spring."

123. For an *Improvement in Dyeing;* John P. Derby, Assignor to the Salisbury Manufacturing Co., Amesbury, Massachusetts.

Claim.—"The protecting of certain portions of the fabric from the action of the dye by a resinous compound, which may be applied cold, and afterwards removing the same by water, diluted alcohol, or the other means herein enumerated."

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124. For an *Improvement in Puppet Valve;* Robert P. Bradley, Cuyahoga Falls, Ohio.

Claim.—"1st, The construction of a puppet valve of the form of a cylinder of the full size of, or larger than the exterior of the face of the valve, with its face at the bottom, and with grooves in the sides. 2d, When the outlet of the valve chamber is at the side thereof, I claim forming a passage around the valve by making a groove around the interior of the chamber, and a similar groove around the exterior of the valve, to form a passage around the grooved cylindrical puppet valve, to form a passage of an area sufficient for the free escape of water at the outlet of the chamber."

125 For an *Improved Machine for Making Brass Kettles;* Edward C. Blakeslee, Enoch Platt, Jr., and Edmund Jordan, Waterbury, Connecticut.

Claim.—"The combination of the revolving female die, and its disk or rim, with the male die, when these are combined with the adjustable reducing rollers."

126. For an *Improvement in Locks;* William H. Butler, City of New York.

Claim—"Placing the case on an arbor or pin, which is secured in the jamb or casing

of the door, the parts being arranged so that said case may be secured or locked on the arbor or pin, or allowed to be detached therefrom, without the aid of a key, whereby the device may be used as a lock or as a button."

127. For an *Improvement in Machines for Bending Sheet Metal;* George W. Burling, Trenton, New Jersey.

Claim.—"1st, The combination of the bars with the folding bar. 2d, The loose plates, in combination with the aforesaid bars."

128. For an *Improved Tooth Extractor;* Hazen J. Batchelder, West Fairlee, Vt.

Claim.—"The improved dental instrument, or combination of forceps, the latching mechanism, the supporting shank and handle."

129. For an *Improved Apparatus for Applying Freezing Mixtures to the Teeth;* Isaac B. Branch, Galena, Illinois.

Claim.—"The employment of instruments for applying cold as an anaethetic of the lip or lips. 2d, The combination with said instrument, or the application thereto, of the spiral spring and follower, or of their equivalent."

130. For an *Improved Arrangement of Buckets of Paddle Wheels;* Matthew A. Crooker, City of New York.

Claim.—"The improved method of arranging the buckets or floats of a paddle-wheel, when the buckets are to be broken into sections; that is to say, by arranging each set or section of buckets along four arcs which circumscribe the periphery, and which arcs are struck with a radius greater than the semi-diameter of the wheel; each set of buckets when placed upon the shaft being arranged so that the place where the arcs of the one set meet, shall stand opposite to the centre of an arc in the adjoining set, if the wheel be composed of but two sections, or when of more than two sections shall be divided proportionally."

131. For an *Improvement in Mould Candle Machines;* William C. Childs, Boston, Massachusetts.

Claim.—"Arranging the wick centering plate in the trough of the candle moulds, and on the bottom of said trough. Also, so applying the front board to the bottom board of the trough, that said front board may be turned down or removed from the trough, in order that the vertical edge or front part of the surplus fat in the trough may be exposed for the purpose of facilitating the removal of said surplus fat from the candles."

132. For an *Improved Method of Fastening Jewelry;* John B. Coppinger, City of New York.

Claim.—"The method of fastening jewelry, &c."

133. For an *Improved Current Wheel;* Plumer Chesley, Candia, New Hampshire.

Claim.—"1st, The regulators. 2d, The entire arrangement for starting and stopping the wheel."

134. For an *Improvement in Cooking Stoves;* John W. H. Doubler, Stephenson Co., Illinois.

Claim.—"The arrangement of the upper stationary doors set back, and lower set of doors, the latter being attached to the rising and falling grate, and hung and arranged so as to slide upwards, over, or against the upper doors when elevating the grate to raise or reduce the size of the fire, said lower sliding doors being provided with a damper or slide, whereby the same relative position of front draft opening to the fire is maintained, whatever the varied set in altitude of the sliding grate, and whereby, while a large amount of door surface is provided the furnace or stove, but a portion only of the weight of said doors has to be lifted in elevating the sliding grate."

135. For an *Improved Method of Preserving Dead Bodies;* John A. Gaussardia, Washington, District of Columbia.

Claim.—"Injecting the body with a mixture of arsenical pyroligneous acid, and then charging it with a current of electricity, and then filling the coffin in which the body is placed, and which is afterwards hermetically sealed with an alcoholic mixture of arsenic, together with the oils of cicuta, and caryophyllus aromaticus."

136. For an *Improved Gas Generator;* Charles A. Howard, Pontiac, Michigan.

Claim.—"The series of inclined retorts."

137. For an *Improvement in Seed Planters;* Jesse D. Havis, Perry, Georgia.

Claim.—"The vibrating hopper, in combination with the pin."

138. For an *Improvement in Evaporators for Salts;* John R. Hopkins, Auburn, N. Y.

Claim.—"The apparatus for the evaporation of solutions whose solvent capacities are increased by the application of heat, and diminished by cooling, consisting of a close boiler, in combination with one or more vats or reservoirs."

139. For an *Improvement in the Handles of Agricultural Forks, Shovels, and Hoes;* Reuben M. Hine, Throopsville, New York.

Claim.—"The improvement of making the handle of an agricultural fork, shovel, hoe, or equivalent implement, of a metallic tube filled with wood."

140. For an *Improved Water Wheel;* George E. W. Herbert, Cohocton, New York.

Claim.—"The flanches, in combination with the inclined position of the buckets."

141. For an *Improvement in Smut Machines;* Harvey B. Ingham, Camptown, Penna.

Claim.—"1st, The receptacle, arranged and operating in combination with the blast tubes and heating cylinder. 2d, The arrangement for discharging the grain by its centrifugal action, at an aperture on the upper side of the heating cylinder, and through a channel eccentrically around the blast pipe, whereby the grain is thrown into the blast higher in the pipe and is distributed more evenly therein."

142. For an *Improved Perch Coupling for Carriages;* Wm. S. Lord, Pulaski, Tenn.

Claim.—"Coupling the fore axle tree of a carriage or other vehicle, to the perch, by means of a cross-bar attached to the perch at a suitable distance in rear of the axle, in combination with connecting links."

143. For an *Improvement in Soap Mixtures;* George C. Lawrence, Winchester, Mass.

Claim.—"The combination of the soap compound with borax, in a pulverized or granular state."

144. For an *Improvement in Washing Machines;* Josiah Mumford and John W. Wilson, Clarksburg, Ohio.

Claim.—"In combination with a rotating tub, having radial ribs on its bottom, a stationary rubbing board, also provided with radial ribs, and radial slots between them, through which any particular portions of the soiled clothes may be protruded to be washed, without washing the entire piece, which lies on top of said rubbing board."

145. For an *Improvement in Suspension Hook and Insect Insulator;* Joseph C. Moulton, Fitchburg, Massachusetts.

Claim.—"A new or improved article of manufacture, composed of a screw-rod, cup, and a hook."

146. For an *Improved Ivory Bleaching Apparatus;* John Phyfe, City of New York.

Claim.—"The bleaching of ivory by exposure to the rays of the sun on a glass table with a reflector below it."

147. For an *Improvement in Stoves and Furnaces;* S. T. Savage, Albany, N. Y.

Claim.—"The use of the throat, aperture or passage surrounded by an air chamber, and pierced with numerous small holes through which atmospheric air passes in numerous small jets to the said throat, when the said throat is located between the fire chamber and a flue chamber leading to the exit pipe or chimney, and combined with a perforated plate interposed between the said throat and the fire."

148. For an *Improvement in Machines for Husking Corn;* Wm. H. Smith, Newport, Rhode Island.

Claim.—"The combination of the toothed disk wheel, elastic endless apron and brush cylinder, arranged and operating conjointly."

149. For an *Improvement in Oil Cans;* James M. Thompson, Holyoke, Massachusetts.

Claim.—"My improved arrangement of oil catching cup or recess, tube, chamber, tube, reservoir, and discharge tube."

150. For an *Improved Dumping Wagon;* Wm. B. Twiford, Horntown, Virginia.

Claim.—"The so hinging of the reach bars and the bed, to a bent axle, as that when

said axle is allowed to turn in one direction in the hubs, the wagon body shall dump, and when turned in the opposite direction, be raised up horizontally, without one part being disconnected to slide or run on the other part."

151. For an *Improved Mode of Securing Sheet Metal Coverings for Roofs;* Wm. H. Trissler and John Stewart, Fairview, Pennsylvania.

Claim.—"The double lapping joint for uniting the sheets of metal without solder. Also, the combination of the scroll and wing edges, for uniting the strips of covering."

152. For an *Improvement in Washing Machines;* Moses D. Wells, Morgantown, Va.

Claim.—"The reciprocating clothes rack, in combination with the wings."

153. For an *Improvement in Breech Loading Fire Arms;* Thornton A. Washington, U. S. Army.

Claim.—"The revolving cylinder breech, having the funnel passage, and the interior flanched cylinder, in combination with the chamber and breech seat."

154. For an *Improvement in Shaft Tugs;* Wm. Wentz, Geneva, New York.

Claim.—"The new manufacture of shaft tug described, viz: a metal shaft tug, provided with a buckle for the back strap, and a loop for the trace, either with or without a loop for the belly band."

155. For an *Improvement in Metallic Pens;* John Wilcox, Philadelphia, Penn.

Claim.—"The double pointed pen, in combination with the flanched swivel plate and slide piece."

156. For an *Improved Back Band Hook for Plough Harness;* Noah Warlick, Chambers County, Alabama.

Claim.—"The reverse hook, in combination with the guard enclosing the same."

157. For an *Improvement in Breech Loading Fire Arms;* George W. Morse, Baton Rouge, Louisiana.

Claim.—"Inserting the rim, or its equivalent, without contact, into the chamber—contact being attained through the medium of a cartridge case. Also, the nippers and the mode of operating them by the pins, and the shoulders on the hammer, or equivalents therefor. Also, the combination of movable parts, or their equivalents, whereby I retract or deliver the gun of a cartridge, drop it, open and clear the way for the insertion of another cartridge, whether the previous charge was fired or failed to fire, and cock the hammer automatically at one motion."

158. For an *Improvement in Cartridges;* George W. Morse, Baton Rouge, La.

Claim.—"The combination and arrangement of the cartridge case as constructed, with the priming apparatus as constructed, or their equivalents, whereby I effect the entire exclusion of any and all escape of the gas produced by the combustion of the powder of the cartridge and priming, except by the one channel, the bore of the barrel of the gun—the breech joints and priming vent being thereby so effectually sealed and closed that no air can escape at these parts of the gun after the charge is fired, until the cartridge case is withdrawn from the bore, although air blown in at the muzzle before firing the charge might escape through these joints, as it would in the case above referred to."

159. For an *Improvement in Railroad Car Coupling;* D. Lynahon and Charles J. Wing, Assignors to D. Lynahon, Buffalo, New York.

Claim.—"The construction of the coupling, viz: having the cross-bars, with pins attached, and encompassed by springs, the bars and springs being placed in the boxes, and the shackles formed with inclined planes at their ends."

160. For an *Improvement in Working Over Vulcanized India Rubber;* Henry Forstrick, Hoboken, New Jersey.

Claim.—"The manner of extracting inorganic matter from vulcanized india rubber, gutta percha, and other gums, or their compounds, by the application of diluted nitric acid, and the use of fusel oil (grain oil,) either in a heated state mixed with the gum, or in the shape of vapors for the restoration of the cleansed gums to the state of cohesion."

161. For an *Improved Projectile for Ordnance;* John B. Read, Tuscaloosa, Alabama.

Claim.—"The attachment to elongated shot or shells of a cylinder of wrought iron

fastened to the body of the shot or shell, by having its bottom or sides more or less embedded in the cast metal of which the shot may be composed; the cylinder to be attached to the but of the shot or shell, and its sides to project beyond, being thinned down after a short bevel, to such a degree as exactly to fit the bore of the gun, when the charge is fired, so as to save windage in all cases, and impart rotation when rifle grooves are employed."

162. For an *Improvement in Billiard Table Cushions;* William B. Carpenter, Brooklyn, New York.

Claim.—"The mode of the fastening of the metallic spring strip or facing, firmly at or near its entire lower edge."

Re-Issues for October, 1856.

1. For an *Improvement in Furnaces for Burning Wet Fuel;* Moses Thompson, New Orleans, Louisiana; patented April 10, 1855; re-issued October 7, 1856.

Claim.—"The combustion, for the purposes of a high or very wet and green wood, by the employment of a series of fire chambers, to communicate with one common flue or mixing chamber, when any number of said chambers are nearly closed to the admission of air when charged, whilst the remaining chamber or chambers are in full communication with the flue, and has a free supply of air admitted, and the ash-pit of each chamber in its turn is nearly closed and then opened, and has air admitted, whereby the heat required is rendered continuous and comparatively uniform, while the fuel in some of the chambers is being heated and decomposed to a desirable degree."

2. For an *Improvement in the Buff for Polishing Spoons and other Articles;* Luther Boardman, East Haddam, Connecticut; patented December 15, 1843; re-issued October 7, 1856.

Claim.—"A cylindrical buff composed of soft leather disks or rings, when the outer portions of said disks are left perfectly free from each other, so as to admit of the yielding necessary to their proper action."

3. For an *Improvement in Manufacturing Hat Bodies;* Charles St. John, Henry A. Burr, Albert H. Wright and James M. Ribbet, Assignees of Henry A. Wells, dec'd., City of New York; patented April 25, 1846; re-issued October 7, 1856.

Claim.—"The forming of the bat of fur fibres on a perforated cone or other form, in combination with the hardening of such bat, while on such cone or other form, to give it the required consistency to admit of taking it off in a suitable condition for sizing by the well known process of felting."

4. For an *Improvement in Door Locks;* John P, Sherwood, Assignor to Calvin Adams, Fort Edward, New York, and re-issued to said Sherwood; patented December 17, 1842; re-issued to said Adams, May 13, 1851; re-issued to said Sherwood, October 7, 1856.

Claim.—"Making the cases of door locks and latches double faced, or so furnished that either side may be used for the outside, in order that the same lock or case fastening may answer for a right or left hand door. Also, the peculiar construction and double action (upon an inclined and horizontal track or way) of the locking and safety cars with one another, and with the connecting or vibrating bar and bolt, so as to fasten the bolt securely, and prevent its being picked. Also, so constructing the bolt, that by simple turning it over in the lock case, it is adapted to a right or left-hand door."

5. For an *Improvement in Artificial Stone;* St. Julien Ravenel, Charleston, South Carolina; patented August 12, 1856; re-issued October 14, 1856.

Claim.—"The composition of marl and slacked lime, substantially in the proportions for producing an artificial stone, or a substitute for stone and bricks."

6. For an *Improvement in Self-sealing Cans;* Robert Arthur, Philadelphia, Penna.; patented January 2, 1855; re-issued June 10, 1856; re-re-issued October 14, 1856.

Claim.—"1st, For a vessel made with a groove to surround its mouth, prepared with cement, and ready for hermetically sealing itself, I make no claim; but, 2d, I claim the employment of elastic packing, arranged and retained by a groove of an acute form, or whose sides are in close proximity."

7. For an *Improved Boring Machine;* Arcalous Wyckoff, Assignee of Wyckoff & Morrison, Elmira, New York; patented September 23, 1855; re-issued Oct. 14, 1856.

Claim.—"1st, The tubular or hollow auger or bits as constructed, having the cutting lips of the bits approach the centre, and yet separated from each other, doing without the use of a screw on the end of the bit, for the purpose of preventing the bit from following the grain of the wood. 2d, The worm, operating on its own axle, and independent of the revolutions of the auger or bits, for the purpose of cleaning away the chips."

8. For an *Improved Piano-Forte Action;* Daniel H. Shirley, Boston, Massachusetts; patented November 28, 1854; re-issued October 21, 1856.

Claim.—"The peculiar manner in which the back catch and the lifter, or its equivalent, are combined together, and with the key-lever, viz: by a lever hinged to the key-lever, and fastened to both back catch and lifter."

9. For an *Improvement in Reversible Horse Power;* Philip H. Kells, Hudson, N. Y.; patented July 8, 1856; re-issued October 28, 1856.

Claim.—"Constructing the horse power so that the converge gear may be shifted to, and secured upon, either end of the main shaft, so that by reversing the pulley and pinion with their shaft, and placing their converge gear upon the proper end of the main shaft, the machine may be converted from a right to a left-hand one, or vice versa, without removing the main shaft."

10. For an *Improved Apparatus for Heating by Gas;* Wm. F. Shaw, Boston, Mass.; patented February 26, 1856; re-issued October 28, 1856.

Claim.—"The combination and arrangement of air and gas burners, or distributors, chambers, and their flue and air supply conductors, in combination with the gas burner, the perforated or wire gauze tube."

11. For an *Improvement in Harness Saddles;* O. B. North & Co., New Britain, Connecticut, Assignees (through immediate assignment) of A. H. Gazlay, deceased.

Claim.—"The manner of constructing harness saddles, in making the jockey skirts and saddle of metal cast in one piece."

DESIGNS FOR OCTOBER, 1856.

1. For *Parlor Cooking Stoves;* Daniel Wilson, Nashua, New Hampshire; Oct. 7, 1856.

Claim.—"The design, configuration, and arrangement in bas-relief on the ends and front of the stove."

2. For *Cylindrical Coal Stove;* Russel Wheeler and Stephen A. Bailey, Utica, New York; October 7, 1856.

Claim.—"The general design and configuration of the stove."

3. For *Cooking Stoves;* Hudson E. Bridge, St. Louis, Missouri; October 7, 1856.

Claim.—"The ornamental configuration, composing a design for a cooking stove."

4. For *Busts of J. C. Fremont;* John Gott, Albany, New York; October 7, 1856.

Claim.—"The new and original design of a bust of Col. John C. Fremont."

5. For *Stoves;* N. S. Vedder and Wm. L. Sanderson, Troy, N. Y., Assignors to North, Chase & North, Philadelphia, Penna.; October 7, 1856.

Claim.—"The design and configuration of the ornamental plates, forming an ornamental design for stoves."

6. For *Stoves;* S. W Gibbs, Albany, N. Y., Assignor to North, Chase & North, Philadelphia, Penna.; October 7, 1856.

Claim.—"The design and configuration of the ornaments forming an ornamental design for stoves."

7. For *Parlor Stoves;* Jacob Beesley and Edward J. Delany, Assignors to Cresson, Stuart & Peterson, Philadelphia, Penna.; October 7, 1856.

Claim.—"The design for parlor stoves."

8. For *Cooking Stoves;* N. S. Vedder, Assignor to Graff, Resinger & Graff, Troy, New York; October 7, 1856.

Claim.—"The use of the patterns or devices for ornamenting the side pieces, front and back pieces of cooking stoves."

9. For *Cooking Stove Plates;* N. S. Vedder, Assignor to Mann, Torrance & Co., Troy, New York ; October 7, 1856.

Claim.—"The ornamental design for panels of plates of cooking stoves."

10. For *Stoves;* Garrettson Smith, Henry Brown, and Joseph A. Read, Assignors to Hayward, Bartlett & Co., Philadelphia, Penna. ; October 7, 1856.

Claim.—"The design, configuration, and arrangement of the ornaments in bas-relief and moulding, constituting an ornamental stove design."

11. For *Stoves;* Hudson E. Bridge, St. Louis, Missouri; October 14, 1856.

Claim.—"The configuration composing an ornamental design for the top, base, and door of a sheet iron air tight stove."

12. For *Cook Stoves;* N. S. Vedder and Wm. L. Sanderson, Troy, Assignors to G. W. Eddy, Watertown, New York; October 21, 1856.

Claim.—"The ornamental design and configuration of cook stove plates."

13. For *Statues of Burton as Captain Cuttle;* Charles Muller, City of New York; October 21, 1856.

Claim—"For a statue of Mr. Burton as Captain Cuttle."

MECHANICS, PHYSICS, AND CHEMISTRY.

*The Gums and Resins of Commerce.** By P. L. Simmonds.

The Elastic Gums are among the most important and generally useful that come into commerce, and although at present confined to two varieties, there is no reason why additions should not be made to the list, and investigation promoted to elicit the comparative value of others. The rapid progress of the submarine telegraph, setting aside other important commercial uses of gutta percha, loudly calls for fresh supplies. If no other purpose had been subserved by this Indian gum than that of encasing the telegraph wires, mankind would have reason to be eminently grateful to the discoverers, and to the Society of Arts for the reward and publicity given to its merits.

We can all recollect when the only uses to which india-rubber was applied, was to rub out pencil marks, and make trap-balls for boys, but now it is made into shoes and hats, caps and cloaks, foot-balls and purses, ribbons and cushions, boats, beds, tents, and bags; into pontoons for pushing armies across rivers, and into camels for lifting ships over shoals. It is also applied to a variety of other uses and purposes, the mere enumeration of which would be tedious. New applications of it are indeed continually being made.

Boundless forests of the Serang tree are found upon the banks of the Amazon, and the exportation of this elastic gum from the mouth of that river is daily becoming a business of more and more value, extent, and importance.

Already within the past five years we have doubled our imports from Brazil (besides the large quantities which the United States draw from thence), and we have also increased our supplies of this elastic gum from the East, the imports from Singapore having risen from 559 cwt. in 1849, to 3030 cwt. in 1853.

Of substances which may be used as substitutes to some extent for

*From the Journal of the Society of Arts, Lond., November, 1855.

caoutchouc or gutta percha, the inspissated juices of the jack fruits and trees, those from the wild and cultivated bread fruit trees, and the lola tree may be mentioned.

Various species of Indian fig-trees, as *Ficus Radula*, *elliptica*, &c., also furnish portions of the elastic gum of commerce. *Vahea gummifera* likewise supplies caoutchouc. The *Urceola elastica* (which produces the Gintawan of the Malays,) abounds on the islands of the Indian Archipelago ; in Java it is called "bendud."

The concrete milky juice of the *Cryptostigeia grandiflora*—a handsome climber, common in the Madras Peninsula—has long been known to contain caoutchouc, but it has not yet been collected for the purposes of commerce, and it is doubtful if a sufficient quantity could be obtained to render it an article of trade. The milk from the cow tree appears to contain caoutchouc. It is supposed to be obtained from *Tabernæmontana utilis* of Arnot, or a species of *Brosimum*. On the river Demarara the Indians climb the rubber tree, tap the trunk, and as the gum exudes, rub it on their bodies till it assumes a sufficient consistency to be formed into balls.

Recent inquiry has shown that caoutchouc is furnished of good quality, by a large number of milky-juiced plants belonging to different families (*Sapotaceæ*, *Apocynaceæ*, and *Euphorbiaceæ*). In the East, Assam now furnishes large quantities of india rubber from *Ficus elastica*. Complaints are, however, made of the want of care in the preparation of the article from Assam.

If the previous purifying of the gum be properly attended to—and in this process the whole art of manufacturing the perfectly elastic gum of commerce seems to exist—the gum should not, by any exposure to the atmosphere, be subject to the least degree of clamminess or viscidity ; and if this important point be not fully attained, the article is of no use in the manufacture of those fine elastic threads which constitute its chief value in the European markets. The art of obtaining this complete freedom from clamminess, and consequent perfect elasticity, does not appear by any means to have been reduced to a certainty ; and, consequently, a far better acquaintance with the article than is yet possessed by the Assam manufacturers seems requisite before it can be obtained with constantly the same results.

A substance resembling caoutchouc was said to have been obtained in Sierra Leone from a plant of the Euphorbia tribe, so long ago as Tuckey's voyage up the Congo, in 1816. Some large forest trees, belonging to the Sapotaceæ family, which abound at the foot of the Ghauts, N. E. of Trevandrum, furnish a valuable elastic gum, called by the Malays pauchouthee, which bears a strong resemblance to gutta percha both in external appearance and mechanical properties, and the real *Isonandra gutta*, would appear to be common in the forests of the Neilgherries.

Gutta Percha has been discovered in the British province of Mergui, and though not precisely identical with the gutta percha of commerce, it possesses all the valuable properties of that substance, including plasticity in hot water, and the power of insulating electric currents.

The tree from which the true gutta taban is produced (erroneously misnamed in Europe gutta percha, a gum yielded by a different tree), is

one of the most common in the jungles of Johore and the Malay Peninsula. It is not found in the alluvial districts, but in undulating or hilly ground. There is a great uniformity in the size of the full grown tabans, which rise with perfectly straight trunks from 60 to 80 feet in height, and from 2 to 3 feet in diameter, the branches being few and small. The natives, after felling the tree, make an incision round it, from which the milk flows. This is repeated at distances of 6 to 18 inches along the whole trunk. It appears that the taban, or milky juice, will not flow freely like dammer and caoutchouc, but rapidly concretes. Its appearance in this state before being boiled is very different from that of the article as imported into Singapore, and thence shipped to Europe. It has a dry, ragged look, resembling shreds of bark, and instead of being dense and tough, is light, and possesses so little cohesion that it is easily torn in pieces.

Various statements are made as to the produce of each tree, which is somewhat surprising, considering the uniform size of the trees. The extremes mentioned are two catties and fifty catties. Dr. Oxley takes the average yield at ten catties, but probably five would be nearer the mark, hence it would take twenty trees to produce one picul of gutta, or 133 lbs., and as the exports of gutta percha, from the commencement of the trade up to the close of 1853, have amounted to 3107 tons, it follows that upwards of one million trees must have been destroyed to obtain that quantity in nine years. The natives, however, do not appear to be under any apprehension that the trees will be extirpated, and smile at the probability when suggested, for it is only trees arrived at their full growth, or at least at a very considerable age, that repay the labor of felling them and extracting the gutta, and those of all inferior ages which are therefore left untouched, will, it is supposed, keep up the race.

The collection of the gutta has widely extended, embracing now the Johore Archipelago, Sumatra, Borneo, and Java. Unfortunately, the quality has deteriorated by the admixture of gutta percha, jelotong, gegrek, litchin, and other inferior gums, the products of different trees, which are often used to adulterate the taban.

The Gitah Lahoe is the produce of *Ficus cerifera*, Blume, which promises to be of great importance in an industrial point of view. The natives of Sumatra form torches of it, which burn with a clear flame, but make a great deal of smoke. A hydro-carbon, closely resembling Cullemundoo gum, from Jaulhna, was shown this year at Madras, obtained from *Euphorbia tirucalli*. It differs considerably from caoutchouc or gutta percha in its physical qualities.

The milky juice of the Muddar plant of India (the *Asclepias* or *Calotropus gigantea*), gradually dries and becomes tough and hard. like gutta percha. It thrives on the poorest soils, and also furnishes an excellent fibre, useful in the place of hemp and flax.

The juice of the sappodilla plum tree, the *Achras sapota* of the West Indies and South America, is slightly adhesive to the touch, but it differs from gutta percha by becoming adhesive and extremely glutinous after being immersed in boiling water, while gutta percha immediately on exposure to a cooler temperature regains its original toughness and flexibility.

An elastic gum resin from an Australian Ficus was shown at Paris in the New South Wales collection, in small tears, of a dingy appearance, which might prove useful. A large portion dissolves in warm linseed oil, but spirits of wine does not act readily on it. By mastication it becomes tenaceous and bleaches thoroughly.

The Royal Patriotic Society of Havana endeavored to introduce the cultivation of the *Ficus elastica*, and other elastic gum-yielding plants, into the Island of Cuba, but their efforts seem not to have succeeded.

The Cullemundoo gum attracted particular attention in 1851, and the exhibitor was rewarded with a prize medal, from the impression of its adaptability to various purposes in the arts. It is obtained from the *Euphorbia antiquorum* of Roxburgh, and this year, at the local exhibition at Madras, the products of two other species, *E. Tirucalli* and *neurifolia*, received honorable notice, although the substances differed in their physical qualities from the true elastic gums of commerce.

An examination of the inspissated gum elastic juices of a number of trees from different localities, and prepared in a different manner, renders it probable that there are a variety of similar vegetable products yet untried, which may be advantageously introduced into commerce. They certainly deserve to be brought specially under the notice of our manufacturers, though as yet many of them are almost unknown to the very natives of the places where they are prepared. Gutta trap, the inspissated sap of an Artocarpus, obtained on the Island of Singapore, and used for making birdlime, was favorably mentioned by the Jurors in 1851.

A few words on the medicinal gums of commerce will serve to bring this lengthy paper to a close.

Gum Ammoniacum.—An opaque cream-colored gum, closely resembling in taste, smell, and general appearance, the ammoniacum of the shops, was gathered by the late Dr. Stocks, in Beloochistan, from the *Dorema aureur*, a tall, umbeliferous plant, described by him in Hooker's *Journal of Botany*, vol. iv, p. 149. He also found there the following fœtid gums, differing from the ordinary ones of English commerce. Gum resin of *Ferula orientalis*, Linn., in semi-transparent, yellowish-brown tears, having a galbanum-like smell, and a strong, bitter, peculiar taste. From another species of Ferula he gathered a pale, yellow, waxy-looking, gum resin, with a somewhat alliaceous and cubeb-like taste. The average imports of ammoniacum in the last few years have been about 400 cwts. Medicinally it is considered the least powerful of the fœtid gum resins.

Euphorbia officinarum, *canariensis*, and some other fleshy species, produce the saline, waxy resin, called in the druggists' shops, Gum Euphorbium, which is the inspissated milky juice of the plant.

Asafœtida (*Narthex asafœtida*), according to the information of Dr. Falconer, who gathered it in among the Dardohs, a wild race of Central Asia, furnishes the Heeng, or asafœtida of commerce.

The plant is found in the greatest abundance in the Persian provinces of Khorhassan and Laar, and thence extends on the one hand into the plains of Toorkistan, upon the Oxus, where it seems to have been met with by Sir Alexander Burnes, and on the other, stretches across from Beloochistan, through Candahar and other provinces of Affghanistan, to the eastern side of the valley of the Indus in Astore. Dr. Falconer did

not meet with it in Cashmere. Captain Burslem, in his Journey in Toorkistan, states that the asafœtida shrub abounded on the hills, and they were almost overpowered by the horrible stench exhaled therefrom. It is collected in its wild state and sent to Cabul and India, yielding a good profit to those who pick it, as it is used very generally throughout the East for kabobs and curries.

Although these fœtid gums are now branded with all sorts of vile names for their offensive odor, yet they were in high repute among the ancients, asafœtida being reckoned one of the most agreeable seasonings for food, and highly esteemed for its medicinal uses, so that it was worth its weight in silver. A stalk of the plant was sent to the Emperor Nero, and yearly to Apollo of Delphos, as more precious than the other productions of the earth, inasmuch, that "he is worthy of silphium," passed into a proverb, (silphium being one of the names by which it was formerly known.) Even in the present day, the Persians and other Asiatics flavor their food with asafœtida, and term it the food of the gods. Tastes we know differ, for by some garlic is highly esteemed, while others detest its flavor. Asafœtida ranks high in the Materia Medica of the Chinese physicians. It forms an important article of trade in the East. The vessels that carry it to the Chinese ports from Bombay, are so imbued with the odor, that they spoil most other goods. Our annual imports of asafœtida range from 50 to 100 tons, but the greater portion is re-exported.

The gum resin called SARCOCOL is seldom now seen in the shops. It has the translucency and much the appearance of gum arabic. In Persia it exudes from all the parts of the *Penœa mucronata*, and in the Cape Colony it is said to be produced on the perianth of *P. Sarcocolla*, and other species of the shrub.

GAMBOGE.—This gum resin is imported to the extent of from 500 to 1000 cwt. annually, and is used in water color painting, and in medicine as a well-known cathartic. Our principal supplies are received from Singapore. Gamboge of good quality was worth there early in the year, 26 dollars the picul, equal to about £4 4s. the cwt. It may be obtained also from Ceylon, where it is produced by the *Hebradendron cambogoides*. The plants furnishing gamboge in other districts are not yet well defined.

Gamboge is obtained in Coorg, Mysore, Canara, Malacca, and Labuan. That from Malacca is the finest pipe variety; all the others are in the form of lumps or tears. The commercial character of this product may be altered by trivial circumstances, the exudation being yellow, reddish, or brown, and of different degrees of solidity, according to the season of the year and the method of manipulation.

The gamboge of the Madras peninsula has been found to be a useful pigment and an effective purgative. It has been lately added to the list of country medicines, and it appears that the tree is so abundant along the coast of the Ghauts, that the product may be obtained in very considerable quantities in the forests of Mysore, Malabar, and Canara. It has been collected there with much care in homogeneous masses, without air vessels, free of woody fibres or other impurities, and is produced by *Garcinia pictoria*, while that from Labuan is probably from *G. Cochin-Chinensis*.

Opium.—This well-known gum, the produce of the capsule of the poppy, enters largely into commerce in the East for stimulating and exciting purposes, and in Europe for medicine. The production in Bengal, chiefly for the supply of China, amounts to between five and six millions a year! Our imports average from 150,000 to 200,000 lbs., and the home consumption has exceeded 60,000 lbs. per annum, on the average of the last four years.

Gum Scammony is the milky juice, or gummy resinous exudation of a plant of the Convolvulus tribe, which is used entirely in medicine, and it is exceedingly difficult to get it genuine. The consumption is not large; the imports in 1853 were 9704 lbs., nearly all from the Turkish dominions.

There are one or two important articles of commerce, which, though not strictly gums or resins, but more properly inspissated extracts, deserve a passing notice; these are the Kinos imported for manufacturing and medicinal use. The Society of Arts early stimulated inquiry and investigation into these products, for the use of the tanner, dyer, &c., and in 1804 the gold medal was awarded to Dr. Howison, for certain useful extracts, and in 1824 Messrs. Pitchey and Wood, of Van Diemens Land, also received the Society's Ceres Medal for other extracts. Sir Joseph Banks had some time previously drawn attention to the value of Terra Japonica, or Gambier. This is an extract prepared from the leaves and branches of the *Uncaria Gambier*, of Roxburgh, cultivated chiefly at Singapore, by the Chinese, and of which our imports average upwards of 91,000 cwt. per annum.

The Cutch of commerce, kuth, or catechu of India, is manufactured in the East from the heart and leaves of the wood of *Acacia Catechu*. Our imports of this substance for tanning, &c., amount to about 35,000 cwt. annually. The sources of supply are Burmah, Bombay, the Concan, and other parts of India. Of this astringent there are now large exports from the Madras territories. Last year (1854) they amounted to 1369 cwts.

There are many samples from Madras, which may be reduced to three varieties:—

1. Circular flat cakes from Travancore, covered on both sides with paddy (rice) husks.

2. Large flat cakes, from the northern division, varying in color from brick-dust to dark-yellow.

3. Round balls of a dark-brown color, the size of a small orange, from Mangalore, where a large manufacture takes place. The exports of Cutch from Calcutta in the last two years have been as follows:—

	1855.	1854.
To Great Britain,	26,624	27,084
France,	8,712	2,812
North America,	2,201	10,007
Indian Maunds,	37,537	39,903

Gambier from Rangoon comes in cubical cakes, covered with a malvaceous leaf.

The genuine Gum Kino of commerce is, as I have already stated, the natural exudation of *Pterocarpus marsupium*, and forms an article of

export to the extent of a few tons from the Malabar coast. Gum butea, from *Butea frondosa*, furnishes the Bengal kino nearly equal to the preceding.

The specimens I have seen are quite identical with the ordinary kino of commerce. Australian kino is obtained from the iron bark tree, a species of Eucalyptus. Jamaica kino from the *Cocoloba uvifera.*

Annual Imports and Estimated Value of the Gums, Resins, Balsams, &c., of British Commerce, including Gum substitutes and Vegetable Extracts:—

Balsams, about	1,000 casks or packages,	£ 14,000
Liquorice Paste,	2,089 cwts.	
" Juice,	9,775 "	
Turpentine,	17,038 tons,	170,380
Tar,	24,500 " at £6,	147,000
Pitch and Petroleum,	6,353 cwts. at 50s. per ton	800
Rosin,	23,000 tons,	115,000
British Gum,	3,000 tons at £42,	110,040
Lac-dye,	18,050 cwts. at £11,	198,550
Seed-Lac,	402 " 25s.,	503
Shellac,	28,512 " 50s.,	71,280
Stick-Lac,	3,000 " 30s.,	4,500
Caoutchouc,	27,588 " £7	193,116
Gutta Percha,	21,792 " £5 10s.,	119,856
Terra Japonica, or Gambier,	4,550 tons at £25,	113,750
Cutch,	1,700 " £30,	51,000
Aloes,	110 " £60,	6,600
Amber,	37 cwt.	
Ammoniac,	28 cwts. at £2,	56
Anime and Copal,	6,000 cwts. at 16s.	96,000
Arabic,	61,614 " 50s.,	153,535
Asafœtida,	400 " 30s.,	600
Benjamin,	900 " £12,	10,800
Dammer,	1,300 " 50s.,	3,250
Dragon's Blood,	190 " £6,	1,140
Galbunum,	24 " £11,	264
Gamboge,	341 " £5,	1,705
Guiacum,	20 " £7,	140
Kino,	250 " £2,	500
Mastic,	430 " £22 10s.,	10,125
Myrrh,	230 " £3,	690
Opium,	159,312 lbs. at 10s.,	79,656
Olibanum,	10,000 cwts. at £2,	20,000
Sandarac,	230 " 70s.,	805
Scammony,	9,704 lbs. at £2,.	19,408
Senegal,	9,000 cwts. at 45s.,	20,250
Tragacanth,	70 tons at £5,	350
Unenumerated Gums,	6,000 cwts. at £2,	12,000

The aggregate market value of these articles, therefore, at the current prices of the day, approximates to two millions sterling.

For the Journal of the Franklin Institute.

Improvement in Drills for Boring Rocks, &c. By John Thomson.

To the Committee on Publications.

Please publish in your valuable *Journal*, one very important and useful purpose to which *fusible metal* may be put with great advantage; that is, to the making of drills for boring rock, more especially in sinking artesian wells.

This new drill I have proved. It consists of an iron cup, with a stem to fit into the other machinery, as the common drill at present does. Into this cup, a suitable number of hard tempered steel chisels are set, and the whole run into one solid tool, by means of the fusible metal; the chisels being spread beyond the edge of the cup, so as to bore any required width of bore hole, and to allow the free passage of water and debris while working.

There is no difficulty in the manufacture of this tool, nor is there any danger of injuring the temper of the steel chisels, as 208 degrees is the melting point of this metal, which is hence quite fluid with boiling water. When finished it will be found solid and strong as if done with melted lead. Modifications of the cup, and also of the chisels, are to be expected, but the idea is here fully advanced, and the advantages of this arrangement of tool I would enumerate. 1st, This drill when reduced in size, or blunted by boring, can be easily heated so as to melt the fusible metal, when the chisels may all be lifted out separately and sharpened; after which they may be set out to the original gauge in the cup of metal, and when cold, the tool is as good as at first (without the aid of a blacksmith). 2d, By using this drill, (having so many cutters,) the hole will always be kept quite circular; the present system often (getting oval and) cornering, and causing a sticking of the tool while working, not easily remedied at all times. 3d, Any size of hole may be bored with this instrument, from the smallest to one of as many feet in diameter as of inches with the present drills, requiring only an increased size of cup, and an indefinite number of chisels as cutters, with, of course, an extra power to work it. This is a very important advantage over the present system of drill boring, and applicable to quarries, and heavy cuttings generally. 4th, In boring very large holes, this drill can never be affected when encountering fissures, inclined strata of variable hardness, nodules, &c. in the rock, so as to drive or lead it off the straight, the area of its face being so large, extending over and embracing the difficulties within its extent, which might prove failures in small deep bearings. No large hole has ever been or can be drilled in hard rock with the present tools, but with this improved drill it can; as it may be worked either horizontally, or in any inclined position, with the same facility as those in present use. I would recommend their immediate adoption, of whatever size. There is work enough ahead in this country for improved drills, for, in addition to boring the earth in search of water or for minerals, we have the prospect of cutting and boring through mountains for railroads and canals, and the rocky barrier in Central America, that separates the Atlantic and Pacific Oceans, must be demolished, before we stop our onward course of improvement; and these things I hope to see accomplished, aided by this improved drill, the use of which admits of plenty of gunpowder being used in blasting, which at present is so limited, on account of the small sized drill, which has been the only boring instrument in use from time immemorial.

In confirmation, and in conclusion, I hold myself in readiness, upon a proper call, to prove to the fullest my invention, which is here so briefly, but I trust intelligibly described.

Fusible metal is a composition of 8 parts bismuth, 5 parts lead, and 3 parts tin.

Philadelphia, Nov. 14, 1856.

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*On the Compounds of Carbon and Iron, and their Influence on the Production of Pig Iron.** By A. GURLT.

(Continued from p. 341.)

After these remarks it will be as well to consider the somewhat modified theory of the production of cast iron, and to follow a charge from the furnace mouth to the crucible. The charge gradually descending as the furnace becomes heated, arrives at the zone of reduction with a temperature of about 400° C. (750° F.) Here the oxides of iron, manganese, sulphur, and phosphorus are gradually reduced, the electro-negative substances combining the moment they are set free with the electro-positive to form metallic sulphites and phosphurets. After the reduction of all the oxides is effected, which is completed about the junction of the belly with the boshes, the charge, now consisting of metal, phosphurets, and sulphurets, with the materials of the slag, enters the zone of carburation, and comes in contact with a large excess of carbonizing gases, viz: oxide of carbon and cyanogen. By its intimate contact with these carbonizing gases and the carbon of the fuel at the high temperature here existing, the reguline metal existing in the state of soft malleable iron uncombined with any electro-negative body becomes carbonized, that is to say, it unites chemically with carbon, which it abstracts from the carbonic oxide and cyanogen gases proportionately as it sinks deeper in the boshes. In most blast furnaces, however, the boshes are considerably contracted at the base, so that the charge is detained, relatively speaking, sufficiently long in this region to combine with its maximum of carbon, passing into the condition of tetracarburet. In the normal working of the furnace then there is always one portion of the iron saturated with carbon when it enters the zone of fusion. In the zone of fusion the pig iron and the earthy matters are melted, and sink together through the hottest part of the furnace, the zone of oxidation, into the crucible, where it collects. If now the temperature existing in the zones of fusion and oxidation were not much higher than the point of fusion of the specular iron, the tetracarburet found in the zone of carburation would arrive undecomposed, and solidify after tapping as white cast iron, with little or no graphite. If the charge remained long enough in the zone of carburation to saturate the whole of the iron with carbon, specular iron would be produced. In either case, however, the whole of the carbon exists chemically combined with the iron, with the occasional exception of that small quantity of graphite separated by silicium which is not visible on the fracture. The reduction of the silicium seems to commence about the melting-point of specular iron as it exists in very small quantity in this kind of iron, and in white cast iron produced from easily fusible ores at a low temperature; in gray cast iron, however, which is known to require a much higher temperature and more refractory ores, it exists in much larger quantity. The very considerable difference of temperature which must prevail in the furnace during the preparation of

* From the Lond. Chem. Gaz., No. 329.

white and gray cast iron, may be judged of from the fact, that with the same ores and fuel the quantity of carbon required to produce gray cast iron will be 50 per cent. greater than is necessary for white cast iron. When, therefore, the temperature of the zones of fusion and oxidation considerably exceeds the melting-point of specular iron, which must always be the case in the preparation of gray cast iron, the tetracarburet formed will be decomposed into octocarburet and carbon, separating in the form of graphite. The melted crude iron arrives in the crucible as octocarburet, and solidifies, after casting, into gray cast iron. By incomplete decomposition of the tetracarburet, mottled cast iron is produced, consisting of a mixture of tetracarburet and octocarburet similar to white cast iron, but distinguishable from this by the particles of graphite disseminated through it.

In order to ascertain how far the views expressed above as to the influence exerted by the carburets of iron on the production of pig iron would agree with the results of analysis, the author calculated a series of the most trustworthy analyses of pig iron by Karsten, Berthier, Bodemann, Bromeis, and others. In this calculation, the fundamental principle was adhered to, that all the electro-negative constituents of the cast iron were chemically combined with the electro-positive according to those known compounds in which the maximum of the latter is contained as $(Fe\ Mn)^4P$, $(Fe\ Mn)^8\ S$, and $(Fe\ Mn)^8\ Si$. The only exception being in the case of the specular iron, where, for the sake of analogy with the carburets, a tetrasiliciuret has been assumed.

The following are the results of the calculation :—

I. White Cast Iron.

Specular Iron from Spathose Iron Ore from Saynerhutte. Karsten.

Carbon,	5·112	$Fe^4\,C$	Fe	94·188	99·300	
Sulphur,	0·601		C	5·112		
Iron,	94·887	$Fe^8\,S$	Fe	0·014	0·015	
Copper,	trace		S	0·001		
	100·000			99 315		

Specular Iron from Lohhutte. Karsten.

Carbon,	5·411	$Fe^4\,C$	Fe	88·099	97·291	
Silicium,	0·366		Mn	4·245		
Sulphur, Phosphorus,	traces		C	4·947		
Iron,	90·797	$Fe^4\,Si$	Fe	1·698	2·064	
Manganese,	4·245		Si	0·366		
Copper,	0·179					
	99·998			99·355		

Specular Iron from Spathose and Brown Iron Ores, Hammhutte. Karsten.

Carbon,	5·140	$(Fe, Mn)^4C$	Fe	89·726	95·606	
Sulphur,	0·002		Mn	0·794		
Phosphorus,	0·080		C	5·086		
Silicium,	0·560	$Mn^4\,Si$	Mn	3·130	3·686	
Iron,	89·720		Si	0·556		
Manganese,	4·300	$Mn^4\,P$	Mn	0·556	0·636	
			P	0·080		
		$Mn^8\,S$	Mn	0·028	0·030	
			S	0·002		
	100·002			99·958		

White Cast Iron, Calder Iron Works, England. Berthier.

Carbon,	1·90	Fe^4C+Fe^8C	Fe	53·750	55·671
Graphite,	0·50		C	1·921	
Sulphur,	1·40	Fe^8Si	Fe	12·108	13·308
Phosphorus,	1·20		Si	1·200	
Silicium,	1·20	Fe^8S	Fe	19·474	20·874
Iron,	93·42		S	1·400	
Manganese,	0·38	Fe^4P	Fe	8·088	9·288
			P	1·200	
		Graphite, ...			0·500
	100·00				99·641

White Cast Iron, Hammhutte. Berthier.

Carbon,	2·910	Fe^4C+3Fe^8C	Fe	95·202	98·112
Sulphur,	0·010		C	2·910	
Phosphorus,	0·080	Mn^8Si	Mn	0·109	0·110
Silicium,	0·001		Si	0·001	
Iron,	95·202	Mn^8S	Mn	0·140	0·150
Manganese,	0·890		S	0·010	
		Mn^4P	Mn	0·528	0·608
			P	0·080	
	99·093				98·980

White Cast Iron from Spathose Iron Ore, Magdesprung. Bromeis.

Carbon,	2·52	Fe^4C+6Fe^5C	Fe	88·532	91·052
Graphite,	0·50		C	2·520	
Sulphur,	trace	Fe^8Si	Fe	3·329	3·659
Phosphorus,	0·40		Si	0·330	
Silicium,	0·33	Mn^4P	Mn	3·270	3·670
Iron,	92·06		P	0·400	
Manganese,	3·27	Graphite			0·610
Copper,	0·11	Copper			
	99·19				98·991

II. Gray Cast Iron.

Mottled Cast Iron from Sphærosiderite, Firmy. Berthier.

Carbon,	1·00	$2Fe^4C+Fe^8C$	Fe	24·84	25·84
Graphite,	0·18		C	1·00	
Sulphur,	3·75	Fe^8Si	Fe	13·11	14·41
Phosphorus,	0·38		Si	1·30	
Silicium,	1·30	Fe^8S	Fe	52·36	56·11
Iron,	93·39		S	3·75	
		Fe^4P	Fe	2·56	2·94
			P	0·38	
		Graphite, ...			0·18
	100·00				99·48

Mottled Cast Iron from Konigshutte, Hartz. Bodemann.

Carbon,	2·78	Fe^4C+Fe^8C	Fe	77·502	80·342
Graphite,	1·99		C	2·780	
Phosphorus,	1·23	Fe^8Si	Fe	7·164	7·874
Sulphur,	trace		Si	0·710	
Silicium,	0·71	Fe^4P	Fe	0·290	9·520
Iron,	93·29		P	1·230	
		Graphite, ...			1·990
	100·00				99·726

Mottled Cast Iron, South Staffordshire. Wrightson.

Carbon,	2·72	Fe^4C +	Fe^8C	Fe	91·310	94·030
Graphite,	0·26			C	2·720	
Phosphorus,	0·37		Fe^8Si	Fe	1·109	1·219
Sulphur,	trace			Si	0·110	
Silicium,	0·11		Fe^4P	Fe	2·493	2·863
Iron,	95·80			P	0·370	
			Graphite,			0·260
Manganese, Calcium, Sodium,	0·74		Mn, Ca, Na			0·740
	100·00					99·112

Gray Pig Iron, Konigshutte, Hartz. Bodemann.

Carbon,	1·44	Fe^8C	Fe	53·726	55·166
Graphite,	2·71		C	1·440	
Sulphur,	trace	Fe^8Si	Fe	32·388	35·598
Phosphorus,	1·22		Si	3·210	
Silicium,	3·21	Fe^4P	Fe	8·223	9·443
Iron,	92·42		P	1·220	
		Graphite,			2·710
	101·00				102·917

Gray Cast Iron from Spathose and Brown Iron Ores, Hammhutte. Karsten.

Carbon,	2·08	$(Fe, Mn)^8C$	Fe	78·70	80·78
Graphite,	2·37		Mu		
Silicium,	1·31		C	2·08	
Phosphorus,	0·08	Fe^8Si	Fe	13·14	14·45
Iron,	86·73		Si	1·31	
Manganese,	7·42	Fe^4P	Fe	0·75	0·83
			P	0·08	
		Graphite,			2·37
	99·99				98·43

Gray Iron from Lancashire Hæmatite. Miller.

Carbon,	2·217	Fe^8C	Fe	82·716	84·933
Graphite,	0·538		C	2·217	
Silicium,	0·951	Fe^8Si	Fe	9·595	10·546
Sulphur,	0·150		Si	0·951	
Phosphorus,	trace	Fe^8S	Fe	2·086	2·236
Iron,	95·777		S	0·150	
		Graphite,			0·538
	99·633				98·253

A glance at the interpretation of the above analyses will be sufficient to show the close agreement between the results assuming the hypothesis of the two subcarburets of iron, and to prove the probable correctness of the views on the theory of the production of pig iron above put forth.

Lastly, to exhibit analytically the influence which the different temperatures at which the respective varieties of cast iron are produced exert on their composition, the author undertook a series of analyses of such varieties of pig iron as were produced from the same ores, fluxes, and fuel, but at different degrees of temperature. These were five varieties from the celebrated iron works of Gartsherrie in Scotland, made from

black band iron-stone with raw coal and limestone from the coal-mea sures. Their chemical composition was as follows :—

	1.	2.	3.	4.	5.
Carbon, .	1·347	1·021	1·793	1·925	2·451
Graphite, .	3·156	2·641	1·110	1·051	0·877
Silicium, .	2·721	3·061	2·165	1·895	1·124
Sulphur, .	1·267	1·139	1·480	1·614	2·516
Phosphorus,	0·842	0·928	1·171	1·811	0·913
Iron, . . .	88·983	90·236	89·314	91·368	89·863
Manganese,	2·401	0·834	1·596	0·571	2·715
	100·717	99 860	98·629	100·235	100·459

1. Very gray iron, with graphite in large flakes; spec. grav.= 7·15.
2. Gray iron with much graphite, but in small flakes; spec. grav=7·21.
3. Mottled gray iron; spec. grav. = 7·21.
4. Mottled gray iron; spec. grav.= 7·25.
5. White cast iron, with radiate crystalline fracture; spec. grav.=7·41.

Of these pig irons 1 and 2 were produced at the highest temperature, that is to say, with the largest consumption of fuel, while in the three others it was diminished. The blast had a considerable pressure, and the air was heated above the melting point of lead for the production of the gray pig.

The above analyses plainly show, that with the diminution of the temperature the amount of the graphite and silicium also diminishes, and, on the other hand, that the chemically combined carbon and the sulphur steadily increase, while the amount of phosphorus varies; for the amount of manganese also no law can be discovered. The large amount of sulphur in these Scotch irons is, no doubt, chiefly owing to a considerable quantity of pyrites often disseminated through the coal used as fuel.

The theoretical calculation of the five analyses agrees with the above assumption that the two varieties 1 and 2 are composed of $Fe^8 C$ and the three others of mixtures of $Fe^8 C$ and $Fe^4 C$, furnishing a new proof of the correctness of the above views on the influence exerted by the carburets of iron on the chemical composition of pig iron.

On the Analysis of Cast Iron.—As the analysis of cast iron is often accompanied with considerable difficulty, and the various methods proposed afford results differing widely from each other, the author gives the following methods made use of by himself, after many comparative trials had convinced him of their advantage and accuracy.

Determination of the Carbon, Graphite, and Silicium.—The substance is placed in a glass flask with about four times its weight of chloride of silver recently precipitated and well washed, a saturated solution of muriate of ammonia poured over it, and allowed to stand ten to twelve days at a moderate temperature. The iron is hereby converted into protochloride and dissolved, but is again decomposed into sesquioxide and sesquichloride by absorption of oxygen. The silicium is oxidized, and the carbon and graphite remain undissolved. When the iron is completely dissolved, the solution is gently boiled with a few drops of hydrochloric acid to redissolve any portions of sesquioxide which may have separated, the contents of the flask are then brought on a filter, and the residue

washed first with water, and afterwards with cyanide of potassium, to dissolve any undecomposed chloride of silver; this must be continued until the filtered fluid no longer exhibits the reactions of silver; the washing is then completed with pure water, and the filter dried and weighed; the weight of the silver, graphite, carbon, and silica is thus obtained; a certain portion of this residue is then boiled for some time with a solution of caustic soda; the silica and chemically combined carbon are dissolved and separated from the silver and graphite, which are weighed, and the difference will give the weight of the former substances.

The solution of soda is evaporated to dryness after being acidulated with hydrochloric acid, redissolved and filtered; the carbon and silica remain on the filter, which is burnt: the weight of the silica is thus obtained, that of the carbon being determined by the difference.

To determine the graphite, it is only necessary to dissolve the silver in dilute nitric acid; the graphite remains unaltered and may be weighed.

Determination of the Sulphur.—It is not advisable to determine the sulphur in cast iron by precipitating the sulphuric acid by a salt of baryta from a solution in aqua regia, as it is difficult to avoid a portion of nitrate of baryta accompanying the precipitate, which cannot afterwards be separated by washing. It is better to dissolve about 1 grm. of the iron in dilute sulphuric acid with the assistance of heat, passing the hydrosulphuric acid gas into a moderately dilute solution of acetate of lead. The sulphuret of lead thereby produced is collected on a filter, well washed, converted into sulphate of lead by means of nitric acid, and weighed.

Determination of Iron, Manganese, and Phosphorus.—From a solution of the iron in aqua regia, in which these substances will exist as chloride of iron, protochloride of manganese, and phosphoric acid, the iron is precipitated by the addition of pure dry carbonate of soda in the cold, accompanied by the phosphoric acid as phosphate of iron, while the manganese remains in solution as carbonate of protoxide of manganese dissolved by the excess of carbonic acid. The precipitate is collected without loss of time, and thoroughly washed with cold water; it is ignited and weighed, and gives the amount of iron and phosphoric acid. A weighed portion of this precipitate is fused with four times its weight of a mixture of $3NaO\,Co^2 + 2KO\,CO^2$, for twenty to thirty minutes, in a platinum crucible, whereby the phosphoric acid is brought into combination with soda; the fused mass is treated with water and filtered, the solution saturated with pure nitric acid, and boiled some time to expel the whole of the carbonic acid; a few drops of acetic acid and solution of acetate of lead are then added, whereupon phosphate of lead is precipitated, which is washed and ignited; it contains in 100 parts, 8·523 of phosphorus. The manganese is easily obtained from the solution in carbonic acid by the addition of caustic soda or potash; the precipitate, which is white, but gradually becomes brown, is collected, ignited, and weighed as deutoxide.

Determination of Zinc.—In some specimens of cast iron minute quantities of zinc are found, which can only be estimated by a separate experiment. From a solution in aqua regia the iron is precipitated by succinate of soda, afterwards the zinc by carbonate of soda; the manganese

remains in solution; the carbonate of zinc is ignited and weighed as oxide of zinc.

Determination of Arsenic and Copper.—Arsenic and copper are precipitated by hydrosulphuric acid from the solution of the iron in aqua regia, separated from each other by sulphide of ammonium, and determined in the usual manner.—*Polytechn. Centralbl.*, 1856, p. 366–379.

"*The Law of the Squares.*"—*Is it Applicable or no, to the Transmission of Signals in Submarine Circuits?** By WILDMAN WHITEHOUSE.

Referring to the proceedings of this section last year at Glasgow, the author quoted Professor W. Thomson's paper on this subject, where he stated "that a part of the theory communicated by himself to the Royal Society last May, and published in the proceedings, shows that a wire of six times the length of the Varna and Balaklava wire, if of the same lateral dimensions, would give thirty-six times the retardation, and thirty-six times the slowness of action. If the distinctness of utterance and rapidity of action, practicable with the Varna and Balaklava wire, are only such as not to be inconvenient, it would be necessary to have a wire of six times the diameter, or better, thirty-six wires of the same dimensions, or a larger number of smaller wires twisted together, under a gutta percha covering, to give tolerably convenient action by a submarine cable of six times the length."

Mr. Whitehouse then stated that circumstances had enabled him to make very recently a long series of experiments upon this point, the result of which he proposed to lay before the section, adding that an opportunity still existed for repeating these experiments upon a portion of cable to which he could obtain access, and that he was ready to show them before a committee of this section in London, if the important nature of the subject should seem to render such a course desirable.

Although the subject of submarine telegraphy had many points of the highest importance requiring investigation, and to the consideration of which he had been devoting himself, the author proposed to confine his remarks on this occasion to the one point indicated in the title—inasmuch as a decision of that one, either favorably or otherwise, would have on the one hand the effect of putting a very narrow limit to our progress of telegraphy, or, on the other, of leaving it the most ample scope. He drew a distinction between the mere transmission of a current across the Atlantic (the possibility of which he supposed everybody must admit), and the effectual working of a telegraph at a speed sufficient for "commercial success," and we gathered from his remarks that there were those ready to embark in the undertaking as soon as the possibility of "commercial success" was demonstrated. He then gave a description of the apparatus employed in his researches, of the manner in which the experiments were conducted, and lastly of the results obtained. The wires upon which the experiments were made were copper of No. 16 gauge, very perfectly insulated with gutta percha, and spun into two cables containing three wires each of equal length (83 miles), covered with iron wires, and coiled in a large tank in full contact with moist

*From the Lond. Civ. Eng. and Arch's. Jour., Sept., 1856.

earth, but not submerged: the two cables were subsequently joined together, making a length of 166 miles of cable, containing three wires. In addition to this, in some of the latest experiments he had also the advantage of another length of cable, giving with the above an aggregate of 1020 miles.

The instruments, one of which was exhibited, seemed to be of great delicacy, capable of the utmost nicety of adjustment, and particularly free from sources of error. The records of the amount of retardation were all made automatically by electro-chemical decomposition on chemically prepared paper. The observations of different distances recorded themselves upon the same slip of paper—thus 0·83, and 249 miles were imprinted upon one paper; 0·83, 498 upon another slip; 0·249, 498 upon another; 0·535, 1020 upon another; thus, by the comparison of the several simultaneous records on each slip, as well as by the comparison of one slip with another, the author has been enabled to show most convincingly that the Law of the Squares is not the law which governs the transmission of signals in submarine circuits. The author showed next, by reference to published experiments of Faraday and Wheatstone, ("*Philosophical Magazine*," July, 1855), that the effect of the iron covering with which the cable was surrounded, was, electrically speaking, identical with that which would have resulted from submerging the wire, and that the results of the experiments could not on that point be deemed otherwise than reliable. He next alluded to the objection raised by Prof. Thomson against experiments in "multiple" cables. Faraday, he said, had experimented upon wires laid in close juxta-position, with reliable results (See "Experimental Researches," vol. 3, page 575); but, in addition to this, our author proposed to himself to answer this objection by an appeal to direct experiments. To decide the question, he first weighed the amount of induction produced in one wire during the use of interrupted or alternating currents in an adjacent wire. A current of eighteen thousand grains thrown into one produced in a length of 166 miles, a current of one grain and a-half by induction in the adjacent and parallel wire; in round numbers, one grain in 10,000,—so slight an amount of interference, in fact, that it may be practically disregarded in this investigation. Indeed, it was found impossible to produce any appreciable difference with reference to the retardation by varying the arrangement of the wires, so that at one time they should carry like currents, at another time unlike, as long as the earth remained part of the circuit. But the author was not without the testimony of most competent persons as additional evidence upon this point. Lieutenant Col. Biddulph, director of the Black Sea Telegraph —the very line to which Prof. Thomson refers—happening to be in England at the time of these researches, went through a series of experiments with our author, and gave as his opinion, "that the phenomena of induction and retardation were as marked, and that there was fully as much, if not more, embarrassment of instruments in these 498 miles of cable as he had met with in the Black Sea line." We may take it as proved, therefore, that experiments on such a cable, fairly and continuously conducted, may be regarded as real practical tests, and the results obtained as a fair sample of what will ultimately be found to hold good

practically in lines laid out *in extenso*. Attention was then called to a table showing the amount of retardation observed at various distances, and under as nearly similar conditions as was possible to obtain. In this are embodied the results of far more labor than meets the eye. At the head of each column is stated the number of observations upon which the result given was computed, every observation being rejected on which there could fall a suspicion of carelessness, inaccuracy, or uncertainty as to the precise conditions; and on the other hand, every one which was retained being carefully measured to the 100th part of a second.

This table is subject to correction for variation in the state of the battery employed just as barometrical observations are subject to correction for temperature. "Of this variation, as a source of error," said our author, "I am quite aware, but I am not yet in possession of facts enough to supply me with the exact amount of correction required. I prefer, therefore, to let the results stand without correction. Now it needs not long examination of this table to find that we have the retardation following an increasing ratio, that increase being very little beyond the simple arithmetical ratio.

"I am quite prepared to admit the possibility of an amount of error having crept in these figures in spite of all precautions. Indeed, I have, on that account, been anxious to multiply observations, in order to obtain trustworthy results; but I cannot admit the possibility of error having accumulated to such an extent as to entirely overlay and conceal the operation of the law of the squares, if, in reality, that law had any bearing on the results. Taking 83 miles as our unit of distance, we have a series of 1, 2, 3, 6, and 12. Taking 166 miles as our unit, we have then a series of 1, 3, and 6. Taking 249 miles, we have still a series of 1, 2, and 4, in very long distances. Yet, even under these circumstances, and with these facilities, I cannot find a trace of the operation of that law."

Table of Retardation observed at Various Distances.

Voltaic Current.—Time stated in parts of a second.

Mean of 550 observations.	Mean of 110 observations.	Mean of 1840 observations.	Mean of 1960 observations.	Mean of 120 simultaneous observations.	
83 miles	166 miles	249 miles	498 miles	535 miles	1020 miles.
·08	·14	·36	·79	·74	1·42

The author then examined the law of the squares, as shown by the value of a current taken in submarine or subterranean wires, at different distances from the generator thereof.

Magneto-electro currents were weighed at Liverpool, which had traveled respectively 40, 120, 240, and 320 miles—from Manchester, Birmingham, London, and Belfast. The results did not confirm the laws of the squares, and the most distant come out with less loss than a comparison of the shorter lengths had led him to anticipate. Another result was even more striking. The voltaic current from a battery of very moderate power, weighed at a distance of 498 miles, in the cable before mentioned, 250 grains on its exit from the wire to earth. Divide the cable into six lengths, and, in accordance with the law of the squares,

at some part of the first length this current ought to be found weighing 36 times 250=9000 grains. This is nearly half as much again as the current actually did weigh at 83 miles, and nearly 1500 grains more than the same current (by observations both at the beginning and end of the experiment,) gave as its maximum lift on short circuit. These observations, by weight, though not possessing, if taken by themselves, the full force which would be due to them had the subject of loss by traveling, and the ratio thereof, been fairly worked out, are yet strongly corroborative of the general results.

"Intimately connected with the consideration of this subject," said our author, "is another which is so closely related to it as to be almost a necessary and integral part thereof. I mean the question of the *size of the conducting wire*. I venture to allude to it now (even though from its importance a subject of special research with me at this moment, and my series of experiments on this point, still in progress and far from complete), because it may be regarded as an appeal to another court for a decision upon the same question put in a different form. The number of wires in the cable enabled me to determine the relative degrees of retardation observable when using a single, double, or treble-sized conductor of the same length in each instance—viz: 166 miles. I had thus to a limited degree the opportunity of testing the application of this law as enunciated by Prof. W. Thomson last year, with reference to the size of conductor necessary, to which I have already alluded. The results, far from confirming the law, are strikingly opposed to it. The fact of trebling the size of the conductor augmented the amount of retardation so as to nearly double that observed in the single wire. I give the actual figures obtained as the mean of one series of thirty-two observations on the point:

Amount of retardation taken at 166 miles:—

Voltaic Current.—Time stated in parts of a second.

Size of conductor.	Mean of 32 observations.
Single,	·15
Double,	·20
Treble,	·17

Velocity as deduced from the foregoing—

Single wire and earth,	1100 miles per second.
Double " "	830 " "
Treble " "	614 " "

These observations were taken again and again with extreme care, were repeated on several days, and with uniformly corresponding results."

The author then stated that the most searching and most practical test, in fact the *experimentum crucis*, would be found in the limit of the rapidity and distinctness of utterance attainable at different distances. He laid before the Section records taken at 498 and 1020 miles. These being taken by the same instrument, and under like conditions, may be regarded as perfectly reliable for comparison with each other, though from being taken with the magneto-electric, instead of voltaic current, and recorded by a new form of instrument, they are not comparable with

results obtained by any of the ordinary form of telegraphic instrument. Three hundred and fifty was the highest number of distinct signals recorded in the minute through 498 miles, and two hundred and seventy through 1020 miles, the former being at the rate of nearly six in the second, the latter four and a half in the second. These figures bear no relation to the squares of the distance—they are even far beyond the simple arithmetical ratio.

"Now, if the law of the squares be held good in its application to submarine circuits, and if the deduction as to the necessary size of the wire based upon that law can be proved to be valid also, we are driven to the inevitable conclusion that submarine cable of certain length, to be successful, must be constructed in accordance with these principles; and what does this involve? In the case of the transatlantic line, whose estimated length will be no less than 2500 miles, it would necessitate the use, for a single conducting wire only, of a cable so large and ponderous as that probably no ship, except Scott Russell's leviathan, could carry it; so unwieldy in the manufacture, that its perfect insulation would be a matter almost of practical impossibility; and so expensive, from the amount of materials employed, and the very laborious and critical nature of the processes required in making and laying it out, that the thing would be abandoned as being practically and commercially impossible. It has been calculated by one intimately connected with this branch of manufacture, and to whom the art of submarine telegraphy owes much of its success, that the first cost of the copper wire alone for a single conductor of such a size would exceed the entire cost of an electric cable containing three circuits of the ordinary gauge; while the amount of money and time involved in making and insulating one of the large size perfectly, is, he says, impossible to arrive at.

"If, on the other hand, the law of the squares be proved to be inapplicable to submarine wires, whether with reference to the amount of retardation observable in them, the rapidity of utterance to be obtained, or the size of the conductor required for the purpose, then we may shortly expect to see a cable not much exceeding one ton per mile, containing three, four, or five conductors, stretched from shore to shore, and uniting us to our transatlantic brethren, at an expense of less than one-fourth that of the large one above mentioned, able to carry from four to five times the number of messages, and therefore yielding about twenty times as much return in proportion to the outlay. And what, it may be asked, is the general conclusion to be drawn as the result of this investigation of the law of the squares applied to submarine circuits? In all honesty, I am bound to answer, that I believe nature knows no such application of that law; and I can only regard it as a fiction of the schools, a forced and violent adaptation of a principle in physics, good and true under other circumstances, but misapplied here."

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*German Telegraphs.**

Experience shows that low prices induce the general use of telegraphs. According to official returns published at Berlin the Prussian telegraphs,

* From the Lond. Athenæum, August, 1856.

which in 1852 did not cover their expenses by 79,831 dollars, had a surplus revenue in 1855 of 101,431 dollars, and the estimates for 1856 figure in the budget for no less than 202,467 dollars. On the 1st of January, 1856, there were in the States comprising the "German and Austrian Telegraph Union," 234 stations, with 11,585 miles of telegraphs opened. Of these, Austria has 69 stations, with 4755 miles; Prussia, 67 stations, with 4575 miles; Bavaria, 32 stations, with 1305 miles; Hanover, 19 stations, with 710 miles; Saxony, 9 stations, with 410 miles; Baden, 7 stations, with 360 miles; Wurtemburg, 5 stations, with 225 miles; Mecklenburg-Schwerin, 5 stations, with 110 miles; and Holland, which has joined the union, 19 stations, with 710 miles.

For the Journal of the Franklin Institute.

Particulars of the Steam Dredger General Moultrie.

Hull built by William Colyer, New York. Machinery by C. H. Delamater, New York. Intended service, Charleston Bar.

HULL.—

Length on deck from fore part of stem to after part of stern post above the spar deck,	150 feet.
Breadth of beam at midship section above the main wales,	26 " 8 inches.
Depth of hold,	10 " 3 "
Draft of water at deep load line,	8 "
" " below pressure and revolutions,	8 "
Area of immersed midship section at this draft,	244 sq. feet.
Tonnage,	365.

ENGINE.—Vertical direct—non-condensing.

Diameter of cylinder,	26 inches.
Length of stroke,	2 feet. 2 "
Maximum pressure of steam in pounds,	60.
Maximum revolutions per minute,	50.

BOILERS.—Two—Cylindrical flued.

Length of boilers,	25 feet.
Diameter, "	4 "
Number of furnaces,	one.
Length of grate bars,	5 "
Number of flues,	two in each.
Internal diameter of flues,	15 inches.
Length of flues,	25 "
Heating surface,	675 sq. feet.
Diameter of smoke pipe,	2 feet 6 "
Height " "	24 "
Description of coal,	Bituminous.

PROPELLERS.—

Diameter of screw,	9 feet.
Pitch of screw,	18 "
Number of blades,	4.

Remarks.—Floor timber, at throat, *molded* 14 ins., *sided* 6 ins. Distance of frames apart *at centres* 26 ins. Well in centre, 45×16 at top, and 45×7 at bottom. Machinery for dredging to be fitted at Charleston.

C. H. H.

*Railway Sleepers.**

Dr. Boucherie, of Paris, states, in reference to the subject,— that:

" The *Times* of the 19th of August gives an account of an experiment, according to my processes for preserving timber, made by the engineers of the Permanent Way Company. This article has called forth from Mr. Bethell, of London, a reply, inserted in the *Times* of the 22d ultimo. I cannot better repel the accusation of plagiarism which Mr. Bethell therein brings against me than by sending to England two official patents which may be seen at the office of the Permanent Way Company, and which have been given me by the French Government, in compliance with two applications for the same which I addressed to it. The first, the 11th of December, 1837, is for the process which I have pointed out, by means of which divers preservative substances are made to penetrate the tissues of wood, employing for that purpose that natural upward force by which the sap is rapidly transferred from the root to the top of the largest trees. Thus a tree of any size was, after being cut down, plunged at its lower end into a tub containing the liquid with which it was to be penetrated. Having found sundry inconveniences in this method of injection, my labors led me to discover a new mode, which I have described on the 30th of May, 1838, applying at the same time for an additional patent. This system consisted in placing one of the ends of a tree in a bag of water-proof cloth, firmly attached to its circumference, which bag communicated with a reservoir containing the liquid. Since then I have considerably modified my plans of operation, and these have been the subject of several subsequent patents. On the 10th of July, 1838 (that is to say, seven months after my first patent, and 42 days after the second), Mr. J. Bethell took out a patent in England for the preservation of wood. In his specification three plans are described. 1. The making the preserving liquid penetrate by capillary attraction,—the natural method described in my patent of the 11th of December, 1837. 2. Penetration by capping with an india-rubber bag communicating with a reservoir,—the mode pointed out in my additional patent of the 30th of May, 1838. 3. Penetration by mechanical vacuum and pressure,—a system the priority of which can be easily claimed by M. Bréant. I leave others to judge to whom belongs the title of inventor. It is true that in 1840 my processes were patented in England in the name of a London merchant, but I do not think that any one is authorized to assume the title of inventor by the single fact that he may have been more in haste than the inventor was to patent in a foreign land the object of his invention, especially when his birth place is only separated by an interval which a few hours suffice to pass over. It does not belong to me to eulogise my discovery; I shall confine myself to saying that it has gained for me at all the French Exhibitions the first gold medals; at the London Exhibition the same reward as was given to Mr. Bethell; and at the Universal Exhibition at Paris one of the four great medals of honor; further, by a special law, unprecedented in France, an extension has been granted to my patent. All my labors and numerous experiments have proved to me that, in proportion as the preservation of the timber takes place before the drying up of the sap in the fibres, it is the more complete if the sap is expelled, to make way for preservative substances.

*From the Lond. Journ. of the Society of Arts, No. 198.

"It is, then, important to subject timber, within two or three months after felling, to that preparation which gives it durability, the limits of which have not yet been found.

"The difficulty in using my process in England is not so great as Mr. Bethell is pleased to represent. Nothing is easier than to have the timber prepared in the midst of the forests which supply the markets of Britain, it is a problem most easy to solve, if but the appeal be made to the fertile intelligence of English industrialists."

For the Journal of the Franklin Institute.

Trigonometrical Developments, and Integration of Trigonometrical Functions. By John M. Richardson.

In mechanical investigations, differential relations, involving trigonometrical expressions, are of frequent occurrence. The integration of these may often be facilitated by using tables of the powers of sines and cosines. Having derived considerable advantage from the use of such tables myself, I venture to offer them to others with the hope that they may prove of general benefit. The method of calculation is also given in order that if any errors occur in transcribing or printing, they may be detected.

For the general process, I am indebted to Boucharlat and De Morgan. (See Boucharlat's Elements de Calcul Differentiel et Integral, and De Morgan's Calculus.)

According to Euler,

$$\left.\begin{aligned} \cos x + \sin x\sqrt{-1} &= e^{x\sqrt{-1}} \\ \cos x - \sin x\sqrt{-1} &= e^{-x\sqrt{-1}} \end{aligned}\right\} \quad . \quad . \quad . \quad (1)$$

Equations (1) being true for all values of x, are true when x becomes mx. Hence,

$$\left.\begin{aligned} \cos mx + \sin mx\sqrt{-1} &= e^{mx\sqrt{-1}} \\ \cos mx - \sin mx\sqrt{-1} &= e^{-mx\sqrt{-1}} \end{aligned}\right\} \quad . \quad . \quad . \quad (2)$$

Raising equations (1) to the mth power,

$$\left.\begin{aligned} (\cos x + \sin x\sqrt{-1})^m &= e^{mx\sqrt{-1}} \\ (\cos x - \sin x\sqrt{-1})^m &= e^{-mx\sqrt{-1}} \end{aligned}\right\} \quad . \quad . \quad (3)$$

Comparing (1), (2), (3), there result:

$$\left.\begin{aligned} \cos mx + \sin mx\sqrt{-1} &= (\cos x + \sin x\sqrt{-1})^m \\ \cos mx - \sin mx\sqrt{-1} &= (\cos x - \sin x\sqrt{-1})^m \end{aligned}\right\} \quad (4)$$

Adding equations (1) together, and putting $e^{x\sqrt{-1}}$ and $e^{-x\sqrt{-1}}$ equal to u and v respectively,

$$\cos x = 2^{-1}(u+v) = 2^{-1}(v+u) \quad . \quad . \quad . \quad (5)$$

Raising (5) to the mth power.

$$\left.\begin{aligned} \cos^{m} x &= 2^{-m}\left[u^{m} + m\, u^{m-1} v + 2^{-1} m\,(m-1)\, u^{m-2} v^2 + \&c. \right] \\ \cos^{m} x &= 2^{-m}\left[u^{m} + m\, v^{m-1} u + 2^{-1} m\,(m-1)\, v^{m-2} u^2 + \&c. \right] \end{aligned}\right\} \quad (6)$$

Adding equations (6),

$$2^{m+1} \cos^{m} x = u^{m} + v^{m} + m\,(u^{m-1} v + v^{m-1} u) + 2^{-1} m\,(m-1)\,(u^{m-2} v^2 + v^{m-2} u^2) + \&c. \text{ or}$$

$$2^{m+1} \cos^{m} x = u^{m} + v^{m} + m\, u\, v\,(u^{m-2} + v^{m-2}) + 2^{-1} m\,(m-1)\, u^2 v^2 (u^{m-4} + v^{m-4}) + \&c. \quad (7)$$

But, since $u = e^{x\sqrt{-1}}$ and $v = e^{-x\sqrt{-1}}$

$$\left.\begin{aligned} u^{m} &= (\cos x + \sin x\sqrt{-1})^{m} = \cos m\,x + \sin m\,x\sqrt{-1} \\ v^{m} &= (\cos x - \sin x\sqrt{-1})^{m} = \cos m\,x - \sin m\,x\sqrt{-1} \end{aligned}\right\} \quad . \quad (8)$$

$$u^{m} + v^{m} = 2\cos m\,x\,; \quad u^{m} v^{m} = 1 \quad . \quad (9)$$

Similarly,

$$\left.\begin{aligned} u^{m-2} + v^{m-2} &= 2\cos(m-2)\,x\,; & u^{m-2} v^{m-2} &= 1 \\ u^{m-4} + v^{m-4} &= 2\cos(m-4)\,x\,; & u^{m-4} v^{m-4} &= 1 \\ \&c. \qquad & \&c. \qquad & \&c. \qquad & \end{aligned}\right\} \quad . \quad . \quad (10)$$

Substituting in (7) it becomes,

$$\left.\begin{aligned} \cos^{m} x = 2^{-(m+1)}\Big[& 2\cos m\,x + 2\,m\cos(m-2)\,x + m\,(m-1) \\ & \cos(m-4)\,x + 3^{-1} m\,(m-1)\,(m-2)\cos(m-6)\,x + \&c. \Big] \end{aligned}\right\} \quad (11)$$

This development contains $(m+1)$ terms, and if $m = 2, 3, 4, 5$, &c., a table of the powers of the cosine of x will be obtained.

Subtracting the last of equations (1) from the first,

$$\sin x = (2\sqrt{-1})^{-1}(u-v) \quad (12)$$

Raising (12) to the power m,

$$\sin^{m} x = (2\sqrt{-1})^{-m}(u-v)^{m} \quad (13)$$

If m is even, $(u-v)^{m} = (v-u)^{m}$ or

$$\sin^{m} x = (2\sqrt{-1})^{-m}(u-v)^{m} = (2\sqrt{-1})^{-m}(v-u)^{m} \quad (14)$$

Developing and proceeding as above,

$$\left.\begin{array}{l}\sin^{m} x=(2\sqrt{-1})^{-m}\Big[\cos m\,x-m\cos(m-2)\,x+2^{-1}m\,(m-1)\\ \cos(m-4)\,x-6^{-1}m\,(m-1)\,(m-2)\cos(m-6)\,x+\&c.\Big]\end{array}\right\} \quad (15)$$

m being even, the imaginary quantity will disappear.

If m is odd $(u-v)^{m}=-(v-u)^{m}$ and,

$$\sin^{m} x=(2\sqrt{-1})^{-m}(u-v)^{m}=-(2\sqrt{-1})^{-m}(v-u)^{m} \quad (16)$$

Hence,

$$2\sin^{m} x=(2\sqrt{-1})^{-m}\Big[u^{m}-v^{m}-m\,u\,v\,(u^{m-2}-v^{m-2})+\&c.\Big] \quad (17)$$

From (10),

$$u^{m}-v^{m}=2\sin m\,x\sqrt{-1};\ u^{m}v^{m}=1;\ \&c. \quad (18)$$

Therefore (17) becomes,

$$\left.\begin{array}{l}\sin^{m} x=2^{-1}(2\sqrt{-1})^{-m+1}\Big[\sin m\,x-m\sin(m-2)\,x+\\ 2^{-1}m\,(m-1)\sin(m-4)\,x-6^{-1}m\,(m-1)\,(m-2)\sin(m-6)x+\&c.\Big]\end{array}\right\} (19)$$

Since m is odd, $m-1$ is even, and the imaginary quantity will disappear.

It must be recollected that,

$$\cos(+x)=\cos(-x);\ \sin(-x)=-\sin(+x) \quad . \quad (20)$$

When m is negative a different process has to be adopted. Since, $\sin^{2}x+\cos^{2}x=1$, $\sin^{-m}x$ and $\cos^{-m}x$ may be multiplied by any power of $\sin^{2}x+\cos^{2}x$, without having their values affected. Hence,

$$\left.\begin{array}{l}\sin^{-m}x=\sin^{-m}x\,(\sin^{2}x+\cos^{2}x)^{\frac{m}{2}}=1+2^{-1}m\cot^{2}x+2^{-3}m\,(m-2)\\ \qquad\cot^{4}x+\&c.\\ \sin^{-m}x=\sin^{-m}x\,(\sin^{2}x+\cos^{2}x)^{\frac{m+2}{2}}=\sin x+2^{-1}(m+1)\cos x\cot x\\ \qquad+2^{-3}(m+1)\,(m-1)\cos x\cot^{3}x+\&c.\end{array}\right\} \quad (21)$$

The first or second of (21) is used according as m is even or odd.

$$\left.\begin{array}{l}\cos^{-m}x=\cos^{-m}x\,(\cos^{2}x+\sin^{2}x)^{\frac{m}{2}}=1+2^{-1}m\tan^{2}x+2^{-3}m\,(m-2)\\ \qquad\cot^{4}x+\&c.\\ \cos^{-m}x=\cos^{-m}x\,(\cos^{2}x+\sin^{2})^{\frac{m+1}{2}}=\cos x+2^{-1}(m+1)\sin x\tan x\\ \qquad+2^{-3}(m+1)\,(m-1)\sin x\tan^{3}x+\&c.\end{array}\right\} \quad (22)$$

The first or second of (22) is used according as m is even or odd.

It is evident that any number of different forms of expansion may be obtained for the same negative power of $\sin x$ or $\cos x$.

It is sometimes more advantageous to have the integral of various expressions in certain forms rather than in others, and, I propose, therefore, to investigate a number of trigonometrical functions, and to give several different expressions for the same integral.

Required the integral of $\sin^m x\, dx$.

CASE I. When m is whole, even, positive.

(1.) Expand $\sin^m x$ by (15), and the integral will be obtained in terms of the sines of multiple arcs.

(2.) $$\sin^m x\, dx = \cos x \sin^m x\, (1-\sin^2 x)^{-\frac{1}{2}}\, dx. \quad . \quad . \quad . \quad (23)$$

Applying the formula for integrating by parts,

$$\int \sin^m x\, dx = m^{-1}\left[\sin^{m-1} x \cos x - (m-1)\int \sin^{m-2} x\, dx\right] \quad . \quad . \quad (24)$$

By repeated application, of (24), the integral will be made to depend upon $\int dx = x$.

(3.) Assume $\cot x = z$; then,

$$\int \sin^m x\, dx = -\int (z^2+1)^{-\frac{m+2}{2}}\, dz. \quad . \quad . \quad . \quad (25)$$

CASE II. When m is whole, odd, positive.

(1.) Expand $\sin^m x$ according to (19); the integral will then be obtained in terms of the cosines of multiple arcs.

(2.) Let $\cos x = z$; then,

$$\int \sin^m x\, dx = -\int \sin^{m-1} x\, d(\cos x) = -\int (1-z^2)^{\frac{m-1}{2}}\, dz. \quad . \quad . \quad (26)$$

$$(3.)\ \int \sin^m x\, dx = \int \cos x\, (1-\sin^2 x)^{-\frac{1}{2}}\, dx = m^{-1}\left[\sin^{m-1} x \cos x - (m-1)\int \sin^{m-2} x\, dx\right] \quad (27)$$

By repeated application of (27), the final integral will depend upon $\int \sin x\, dx = -\cos x$.

CASE III. When m is whole, even, negative.

(1.) Expanding according to the first of (21), it is seen that the final integral will depend upon that of $\cot x\, dx$.

Let $\cot x = z$; then,

$$\int \cot^m x\, dx = -\int z^m (1+z^2)^{-1}\, dz = -(m-1)^{-1}\left[z^{m-1} - (m-1)\int z^{m-2}(1+z^2)^{-1}\, dz\right] \quad (28)$$

The final integral will depend upon $\int (1+z^2)^{-1} dz = \overset{-1}{\tan} z.$

(2.) Let cosec $x = z$; then,

$$\left.\begin{aligned}\int \sin^{-m} x\, dx &= \int \operatorname{cosec}^{m} x\, dx = -\int z^{m-3} (z^2-1)^{-\frac{1}{2}} dz = -(m-3)^{-1} \\ &\left[z^{m-4} + (m-4) \int z^{m-5} (z^2-1)^{-\frac{1}{2}} dz \right]\end{aligned}\right\} \quad (29)$$

Repeated applications of this formula, will cause the final integral to depend upon $\int z (z^2-1)^{-\frac{1}{2}} dz = (z^2-1)^{\frac{1}{2}}.$

(3.) $$\sin^{-m'} x\, dx = \sin x \sin^{-(m'+1)} x\, dx.$$

Let $\sin x\, dx = dv$; $\sin^{-(m'+1)} x = u$; $\therefore v = -\cos x$; $d\ u = -(m'+1)\cos x \sin^{-(m'+2)} x dx$.

Applying the formula for integrating by parts.

$$\int \sin^{-m'} x\, dx = -\cos x \sin^{-(m'+1)} x - (m'+1) \int \cos^2 x \sin^{-(m'+2)} x\, dx.$$

$$\int \sin^{-(m'+2)} x\, dx = -(m'+1)^{-1} \left[\cos x \sin^{-(m'+1)} x - m' \int \sin^{-m'} x\, dx. \right]$$

If $m'+2 = m$, then $m'+1 = m-1$, and $m' = m-$.

$$\int \sin^{-m} x\, dx = -(m-1)^{-1} \left[\cos x \sin^{-m+1} x - (m-2) \int \sin^{-m+2} x\, dx. \right] \quad (30)$$

Case IV. When m is entire, odd, negative.

(1.) Expanding $\sin^{-m} x$ according to the second of (21), it is evident, that the integral of $\sin^{-m} x\, dx$ depends upon that of $\cos x \cot^{m} x\, dx$.

$$\int \cos x \cot^{m} x\, dx = \int \cos^{m+1} x \sin^{-m} x\, dx = \int \sin x \cos^{m+1} x \sin^{-(m+}$$

$$= -\int \cos^{m+1} x \sin^{-(m+1)} x\, d(\cos x) \text{ and,}$$

$$\int \cos x \cot^{m} x\, dx = -\int z^{m+1} (1-z^2)^{\frac{-(m+1)}{2}} dz. \quad . \quad (31)$$

Where $\cos x = z$.

$$(2.) \int \sin^{-m} x\, dx = \int \sin x \sin^{-(m+1)} x\, dx = \int -\sin^{-(m+1)} x\, d(\cos x) = -$$

$$\int (1-z^2)^{\frac{-(m+1)}{2}} dz. \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

$\cos x = z$.

(3.) The integral of $\sin^{-m} x\, dx$, as in (3) of the preceding case, may be obtained by using formula (30). Repeated applications of (30) will cause the final integral to depend upon $\int (\sin x)^{-1} dx \int (\sin x)^{-1} dx =$

$$\int \sin x (1-\cos^2 x)^{-1} dx = 2^{-1} \log (1-\cos x)(1+\cos x)^{-1} = \log \tan 2^{-1} x. \quad (33)$$

CASE V. When m is fractional and positive.

Let $m = r\,s^{-1}$. $\sin x = \sin^{s} z$ then

$$\int \sin^{rs-1} x\,dx = s\int \cos z\,(1-\sin^{2s} z)^{-\frac{1}{2}}\sin^{r+s-1} z\,dz = s\int (1-\sin^{2s} z)^{-\frac{1}{2}}\sin^{r+s-1} z\,d(\sin z)$$

$$\int \sin^{rs-1} x\,dx = s\int (1-u)^{2s-\frac{1}{2}}\,u^{r+s-1}\,du. \quad . \quad . \quad . \quad . \quad (34)$$

Where $u = \sin z$.

CASE VI. When m is fractional and negative.

Let $m = -r\,s^{-1}$ $\sin x = \sin^{s} z$

$$\int \sin^{-rs-1} x\,dx = s\int \sin^{-r+s-1} z\,(1-\sin^{2s} z)^{-\frac{1}{2}}\,d(\sin z) = s\int u^{-r+s-1}\,(1-u)^{2s-\frac{1}{2}}\,du \quad (35)$$

$$u = \sin z.$$

Since $\cos x = \sin(2^{-1}\pi - x) = \sin x'$, $\cos^{m} x\,dx$ is always integrable whatever may be the sign or value of m provided $\sin^{m} x$ is integrable.

$$\int \cos^{m} x\,dx = -\int \sin^{m} x'\,dx' \quad . \quad . \quad . \quad (36)$$

Required the integral of $\sin^{m} x \cos^{n} x\,dx$.

CASE I. When m and n are entire, even positive.

(1.) If $m = n$.

$$\int \sin^{m} x \cos^{n} x\,dx = \int \sin^{m} x\,\cos^{m} x\,dx = 2^{-m}\int \sin^{m} 2x\,dx \quad . \quad (37)$$

(2.) If $m > n$

$$\int \sin^{m} x \cos^{n} x\,dx = \int \sin^{m-n} x \sin^{n} x \cos^{n} x\,dx = 2^{-n}\int \sin^{m-n} x \sin^{n} 2x\,dx$$

$$\int \sin^{m} x \cos^{n} x\,dx = 2^{-\frac{(m+n)}{2}}\int (1-\cos 2x)^{\frac{m-n}{2}} \sin^{n} 2x\,dx \quad . \quad (38)$$

Repeated applications of this formula will complete the integration.

(3.) If $m < n$

$$\int \sin^{m} x \cos^{n} x\,dx = 2^{-\frac{m+n}{2}}\int (1+\cos 2x)^{\frac{n-m}{2}} \sin^{m} 2x\,dx \quad (39)$$

(4.) $$\int \sin^{m} x \cos^{n} x\,dx = \int \sin^{m-1} x \cos^{n} x \sin x\,dx.$$

Let $\sin x \cos^{n} x\,dx = dv$; $\sin^{m-1} x = u$; $\therefore\ v = -(n+1)^{-1}\cos^{n+1} x$;

$$du = (m-1)\sin^{m-2} x \cos x\,dx.$$

Applying the formula for integrating by parts.

$$\int \sin^{m} x \cos^{n} x\,dx = -(m+n)^{-1}\left[\sin^{m-1} x \cos^{n+1} x - (m-1)\int \sin^{m-2} x \cos^{n} x\,dx\right] \quad (40)$$

Repeated applications of this formula will cause the final integral to depend upon that of $\cos^n x\, dx$; which has been provided for.

$$(5.)\qquad \int \sin^m x \cos^n x\, dx = \int \sin^m x \cos^{n-1} x \cos x\, dx.$$

Let $\sin^m x \cos x\, dx = dv$; $\cos^{n-1} x = u$; $\therefore v = (m+1)^{-1} \sin^{m+1} x$

$$du = -(n-1)\cos^{n-2} x \sin x\, dx.$$

Applying the formula $\int u\, dv = uv - v\, du$.

$$\int \sin^m x \cos^n x\, dx = (m+n)^{-1}\left[\sin^{m+1} x \cos^{n-1} x + (n-1)\int \sin^m x \cos^{n-2} x\, dx\right] \quad (41)$$

Hence $\int \sin^m x \cos^n x\, dx$ will depend upon $\int \sin^m x\, dx$; which has been provided for.

Case II. When m and n are whole, odd, positive.

$$(1.)\int \sin^m x \cos^n x\, dx = \int \sin^m x \cos^{n-1} x \cos x\, dx = \int \sin^m x \cos^{n-1} x\, d(\sin x)$$

Let $\sin x = z$; then

$$\int \sin^m x \cos^n x\, dx = \int z^m (1-z^2)^{\frac{n-1}{2}}\, dz. \qquad . \qquad . \quad (42)$$

$$(2.)\int \sin^m x \cos^n x\, dx = \int \sin^{m-1} x \cos^n x \sin x\, dx = -\int \sin^{m-1} x \cos^n x\, d(\cos x)$$

Let $\cos x = z$, then

$$\int \sin^m x \cos^n x\, dx = -\int z^n (1-z^2)^{\frac{m-1}{2}} dz. \qquad . \quad (43)$$

(3.) If $m = n$.

$$\int \sin^m x \cos^n x\, dx = \int \sin^m x \cos^m x\, dx = 2^{-m}\int \sin^m 2x\, dx. \quad (44)$$

(40) & (41) can be employed in this case.

Case III. When m is even and n odd; both positive.

Apply (40), or (41), or (42),

Case IV. When m is odd and n even; both positive.

Apply (40), or (41), or (43).

Case V. When m and n are whole, even, negative.

(1.) If $m = n$,

$$\int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-m} x \cos^{-m} x\, dx = 2^m \int \sin^{-m} 2x\, dx \quad (45)$$

(2.) If $m > n$, since $\sin^2 x + \cos^2 x = 1$.

$$\left.\begin{array}{l} \int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-m} x \cos^{-n} x\, (\sin^2 x + \cos^2 x)^{\frac{m}{2}}\, dx = \\ \int \Big[\cos^{-n} x + 2\tfrac{m}{1} \cos^{-n+2} x \sin^{-2} x + 2\tfrac{m}{3}(m-2) \cos^{-n+4} x \sin^{-4} x + \&c., \\ + 2\tfrac{m}{1} \cos^{m-n-2} x \sin^{-m+2} x + \cos^{m-n} x \sin^{-m} x \Big] dx \quad . \quad . \end{array}\right\} \quad (46)$$

The first term of this development can be integrated by preceding formulas; and by treating each of the other terms in the same manner, the integral will finally be obtained.

(3.) If $m < n$,

$$\left.\begin{array}{l} \int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-m} x \cos^{-n} x\, dx\, (\cos^2 x + \sin^2 x)^{\frac{n}{2}} = \\ \int \Big[\sin^{-m} x + 2\tfrac{n}{1} \sin^{-(m-2)} x \cos^{-2} x + \&c., + 2\tfrac{n}{1} \sin^{-1+(n-m-2)} x \cos^{-(n-2)} x + \sin^{-(m-n)-n} x \cos x \Big] dx \end{array}\right\} \quad (47)$$

Case VI. When m and n are whole, odd, negative.

(1.) If $m = n$,

$$\int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-m} x \cos^{-m} x\, dx = 2^{m} \int \sin^{-m} (2x)\, dx \quad (48)$$

(2.) If $m > n$,

$$\int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-(m-n)} x \sin^{-n} x \cos^{-n} x\, dx = 2^{n} \int \sin^{-(m-n)} x \sin^{-n} 2x\, dx$$

$$= 2^{\frac{m+n}{2}} \int (1 - \cos 2x)^{\frac{-m-n}{2}} \sin^{-n} 2x\, dx = 2^{\frac{m+n}{2}} \int (1 - \cos 2x)^{\frac{-m-n}{2}} \sin^{-(n+1)} 2x$$

$\sin 2x\, dx = -2^{\frac{m+n-2}{2}} \int (1 - \cos 2x)^{\frac{m-n}{2}} \sin^{-(n+1)} 2x\, d(\cos 2x)$. Hence

$$\left.\begin{array}{l} \int \sin^{-m} x \cos^{-n} x\, dx = -2^{\frac{m+n-2}{2}} \int (1-z)^{\frac{m-n}{2}} (1-z^2)^{-\frac{n+1}{2}} dz = \\ -2^{\frac{m+n-2}{2}} \int (1-z)^{\frac{m-n}{2}} (1-z)^{\frac{n+1}{2}}\, dz = -2^{\frac{m+n-2}{2}} \int (1-z)^{\frac{-m+1}{2}} (1+z)^{\frac{-n+1}{2}}\, dz \end{array}\right\} \quad (49)$$

Where $z = \cos 2x$.

$$\left.\begin{array}{l} \int \sin^{-m} x \cos^{-n} x\, dx = \int \sin^{-m} x \cos^{-n} x\, (\sin^2 x + \cos^2 x)^{\frac{m+1}{2}}\, dx = \\ \int \Big[\sin x \cos^{-n} x + 2^{-1}(m+1) (\sin x)^{-1} \cos^{-(n-2)} x + \&c., + 2^{-1}(m+1) \\ \sin^{-(m-2)} x \cos^{(m-n-1)} x + \sin^{-m} x \cos^{(m+1-n)} x \Big] dx. \end{array}\right\} \quad (50)$$

(3.) If $m \prec n$

$$\int \sin^{-m} x \cos^{-n} x \, dx = -2^{\frac{m+n-2}{2}} \int (1+z)^{-\frac{n+1}{2}} (1+z)^{-\frac{m+1}{2}} \, dz \tag{51}$$

Where $z = \cos 2x$.

$$\left.\begin{aligned} &\int \sin^{-m} x \cos^{-n} x \, dx = \int \Big[\cos x \sin^{-m} x + 2^{-1}(n+1) (\cos x)^{-1} \sin^{-(m-2)} x + \\ &\&c., \; + 2^{-1}(n+1) \cos^{-(n-2)} x \; \sin^{(n-m-1)} x + \cos^{-n} x \sin^{(n+1-m)} x \Big] dx \end{aligned}\right\} \tag{52}$$

Case VII. When m is whole, even, positive; n is whole, even, negative.

(1.) If $m = n$;

$$\left.\begin{aligned} &\int \sin^{m} x \cos^{-n} x \, dx = \int \tan^{m} x \, dx = \int (1-\cos^2 x)^{\frac{m}{2}} \cos^{-m} x \, dx = \\ &\int \Big[\cos^{-m} x - 2^{-1} m \cos^{-(m-2)} x + 2^{-3} m (m-2) \cos^{-(m-4)} x - \&c., \mp \\ &2^{-1} m \cos^{-2} x \pm 1 \Big] dx \end{aligned}\right\} \tag{53}$$

(2.) If $m \succ n$;

$$\left.\begin{aligned} &\int \sin^{m} x \cos^{-n} x \, dx = \int (1-\cos^2 x)^{\frac{m}{2}} \cos^{-n} x \, dx = \int \Big[\cos^{-n} x - 2^{-1} m \\ &\cos^{-(n-2)} x + \&c., + 2^{-1} m \cos^{(m-n-2)} x \mp \cos^{m-n} x \Big] dx \end{aligned}\right\} \tag{54}$$

(3.) If $m \prec n$;

$$\left.\begin{aligned} &\int \sin^{m} x \cos^{-n} x \, dx = \int \sin^{-(n-m)} x \sin^{n} x \cos^{-n} x \, dx = \int \sin^{-(n-m)} x \\ &\Big[\cos^{-n} x - 2n \cos^{-(n-2)} x + \&c., \mp 2^{-1} n \cos^{-2} x \pm 1 \Big] dx \end{aligned}\right\} \tag{55}$$

(4.) According to (40).

$$\int \sin^{m} x \cos^{-n} x \, dx = -(m-n)^{-1} \Big[\sin^{m-1} x \cos^{-(n-1)} x - (m-1) \int \sin^{m-2} x \cos^{-n} x \, dx \Big] \tag{56}$$

Case VIII. When m is whole, odd, positive; n whole, even, negative.

$$\left.\begin{aligned} &(1) \int \sin^{m} x \cos^{-n} x \, dx = -(m-n)^{-1} \Big[\sin^{m-1} x \cos^{-(n-1)} x - (m-1) \\ &\int \sin^{m-2} x \cos^{-n} x \, dx \Big] \end{aligned}\right\} \tag{57}$$

$$\left.\begin{aligned} &(2) \int \sin^{m} x \cos^{-n} x \, dx = -\int \sin^{m-1} x \cos^{-n} x \, d(\cos x) = -\int (1-z^2)^{\frac{m-1}{2}} \\ &z^{-n} \, dz \int \sin^{m} x \cos^{-n} x \, dx = -\int \Big[z^{-n} - 2^{-1}(m-1) z^{-(n-2)} + \&c., \\ &2^{-1}(m-1) z^{m-n-3} \pm z^{m-n-1} \Big] dz \end{aligned}\right\} \tag{58}$$

Where $z = \cos x$.

CASE IX. When m is whole, odd, positive; n is whole, odd, negative.

(1.) If $m \gtrless n$;

$$\int \sin^{m} x \cos^{-n} x \, dx = -\int \sin^{m-1} x \cos^{-n} x \, d(\cos x). \quad \text{Hence}$$

$$\int \sin^{-m} x \cos^{-n} x \, dx = -\int \left[1-z^2\right]^{\frac{m-1}{2}} z^{-n} \, dz \tag{59}$$

(2.) Apply (40).

CASE X. When m is whole, even, positive; n is whole, odd, negative.

(1.) If $m \lessgtr n$;

$$\int \sin^{m} x \cos^{-n} x \, dx = \int \sin^{m} x \cos^{-(n+1)} x \cos x \, dx = \int \sin^{m} x \cos^{-(n+1)} x \, d(\sin x)$$

$$\int \sin^{m} x \cos^{-n} x \, dx = \int z^{m} (1-z^2)^{\frac{-(n+1)}{2}} \, dz \tag{60}$$

(2.) Apply (40).

CASE XI. When m whole, even, negative; n is whole, even, positive.

(1.) Since $\sin x = \cos(2^{-1}\pi - x) = \cos x'$; $\cos x = \sin(2^{-1}\pi - x) = \sin x'$,

$$\int \sin^{-m} x \cos^{n} x \, dx = -\int \cos^{-m} x' \sin^{n} x' \, dx' \tag{61}$$

This has been provided for (Case VII).

CASE XII. When m whole, even, negative; n is whole, odd, positive.

$$(1.) \int \sin^{-m} x \cos^{n} x \, dx = -\int \cos^{-m} x \cos^{n} x' \, dx' \tag{62}$$

Where $x' = 2^{-1}\pi - x$. Provided for (See Case VIII).

CASE XIII. When m is whole, odd, negative; n whole, even, positive.

$$(1.) \int \sin^{-m} x \cos^{n} x \, dx = -\int \cos^{-m} x' \sin^{n} x' \, dx' \tag{63}$$

Provided for (Case X.)

CASE XIV. When m is whole, odd, negative; n whole, odd, positive.

$$(1.) \int \sin^{-m} x \cos^{n} x \, dx = -\int \cos^{-m} x' \sin^{n} x' \, dx' \tag{64}$$

Already provided for (See Case IX).

CASE XV. When m and n are fractional.

Let $m = r^{-1}s$; $n = p^{-1}q$ and $\sin x = \sin^{s} z$. Then,

$$\sin^{rs-1} x = \sin^{r} z \, ; \cos^{pq-1} = (1-\sin^{2s} z)^{\frac{p}{q}}; \; dx = s \sin^{s-1} z \, (1-\sin^{2s} z)^{-\frac{1}{2}} \times$$

$$(1-\sin^{2} z)^{\frac{1}{2}} dz \tag{65}$$

$$\int \sin^{rs} x \cos^{pq} x \, dx = s \int \sin^{r+s-1} z \, (1-\sin^{2s} z)^{\frac{p-q}{q}} (1-\sin^2 z)^{\frac{1}{2}} dz \tag{66}$$

Let $\sin z = u$; then $dz = (1-\sin^2 z)^{-\frac{1}{2}}\, du$. Substituting in (66)

$$\int \sin^{rs} x \cos^{pq} x\, dx = s \int u^{r+s-1} (1-u)^{\frac{2s}{2}} \frac{p-q}{q}\, du \qquad (67)$$

Table of powers of Sines with positive exponents.

$$\sin x = -2^{-1} (\cos 2x - 1).$$

$$\sin^3 x = -2^{-2} (\sin 3x - 3 \sin x).$$

$$\sin^4 x = 2^{-3} (\cos 4x - 4 \cos 2x + 3).$$

$$\sin^5 x = 2^{-4} (\sin 5x - 5 \sin 3x + 10 \sin x).$$

$$\sin^6 x = -2^{-5} (\cos 6x - 6 \cos 4x + 15 \cos 2x - 10).$$

$$\sin^7 x = -2^{-6} (\sin 7x - 7 \sin 5x + 21 \sin 3x - 35 \sin x).$$

$$\sin^8 x = 2^{-7} (\cos 8x - 8 \cos 6x + 28 \cos 4x - 56 \cos 2x + 35).$$

$$\sin^9 x = 2^{-8} (\sin 9x - 9 \sin 7x + 36 \sin 5x - 84 \sin 3x + 126 \sin x)$$

$$\sin^{10} x = -2^{-9} (\cos 10x - 10 \cos 8x + 45 \cos 6x - 120 \cos 4x + 210 \cos 2x - 126).$$

Table of powers of Sines with negative exponents.

$$\sin^{-2} x = 1 + \cot^2 x.$$

$$\sin^{-3} x = \sin x + 2 \cos x \cot x + \cos x \cot^3 x.$$

$$\sin^{-4} x = 1 + 2 \cot^2 x + \cot^4 x.$$

$$\sin^{-5} x = \sin x + 3 \cos x \cot x + 3 \cos x \cot^3 x + \cot^5 x.$$

$$\sin^{-6} x = 1 + 3 \cot^2 x + 3 \cot^4 x + \cot^6 x.$$

$$\sin^{-7} x = \sin x + 4 \cos x \cot x + 6 \cos x \cot^3 x + 4 \cos x \cot^5 x + \cos x \cot^7 x.$$

$$\sin^{-8} x = 1 + 4 \cot^2 x + 6 \cot^4 x + 4 \cot^6 x + \cot^8 x.$$

$$\sin^{-9} x = \sin x + 5 \cos x \cot x + 10 \cos x \cot^3 x + 10 \cos x \cot^5 x + 5 \cos x \cot^7 x + \cos x \cot^9 x.$$

$$\sin^{-10} x = 1 + 5 \cot^2 x + 10 \cot^4 x + 10 \cot^6 x + 5 \cot^8 x + \cot^{10} x.$$

Table of the powers of Cosines with positive exponents.

$$\cos^2 x = 2^{-1} (\cos 2x + 1).$$

$$\cos^3 x = 2^{-2} (\cos 3x + 3 \cos x).$$

$$\cos^4 x = 2^{-3} (\cos 4x + 4 \cos 2x + 3).$$

$$\cos^5 x = \frac{-4}{2}(\cos 5x + 5\cos 3x + 10\cos x).$$

$$\cos^6 x = \frac{-5}{2}(\cos 6x + 6\cos 4x + 15\cos 2x + 10).$$

$$\cos^7 x = \frac{-6}{2}(\cos 7x + 7\cos 5x + 21\cos 3x + 35\cos x).$$

$$\cos^8 x = \frac{-7}{2}(\cos 8x + 8\cos 6x + 28\cos 4x + 56\cos 2x + 35).$$

$$\cos^9 x = \frac{-8}{2}(\cos 9x + 9\cos 7x + 36\cos 5x + 84\cos 3x + 126\cos x).$$

$$\cos^{10} x = \frac{-9}{2}(\cos 10x + 10\cos 8x + 45\cos 6x + 120\cos 4x + 210\cos 2x + 126).$$

Table of the powers of Cosines with negative exponents.

$$\cos^{-2} x = 1 + \tan^2 x.$$

$$\cos^{-3} x = \cos x + 2\sin x \tan x + \sin x \tan^3 x.$$

$$\cos^{-4} x = 1 + 2\tan^2 x + \tan^4 x.$$

$$\cos^{-5} x = \cos x + 3\sin x \tan x + 3\sin x \tan^3 x + \sin x \tan^5 x.$$

$$\cos^{-6} x = 1 + 3\tan^2 x + 3\tan^4 x + \tan^6 x.$$

$$\cos^{-7} x = \cos x + 4\sin x \tan x + 6\sin x \tan^3 x + 4\sin x \tan^5 x + \sin x \tan^7 x.$$

$$\cos^{-8} x = 1 + 4\tan^2 x + 6\tan^4 x + 4\tan^6 x + \tan^8 x.$$

$$\cos^{-9} x = \cos x + 5\sin x \tan x + 10\sin x \tan^3 x + 10\sin x \tan^5 x + 5\sin x \tan^7 x + \sin x \tan^9 x.$$

$$\cos^{-10} x = 1 + 5\tan^2 x + 10\tan^4 x + 10\tan^6 x + 5\tan^8 x + \tan^{10} x.$$

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*On the Solubility of Bones in Water.** By Prof. Wöhler.

When bone-dust, such as is commonly employed as manure, is left for some time in contact with water, and the latter is filtered away, it is found to contain appreciable quantities of the phosphates of lime and magnesia. The same result is obtained when the water is freed from carbonic acid by long boiling. By filtering water for months through the same mass of bone-dust, it was found constantly to contain these earthy phosphates, and their quantity even appeared to increase in proportion as the organic matter of the bones became putrid in consequence of its long contact with water and air, and the water flowing off became turbid and offensive. This fact seems to have some practical value in agriculture, as it shows that without any artificial preparation the earthy phosphates may be extracted from the bones and introduced into the soil in a state of solution, perhaps exactly in the quantity necessary for their appointed functions, and that in the employment of bone-dust as manure, all the preparation necessary is perhaps to lay it in heaps during the summer, and keep it constantly moist.—*Liebig's Annalen*, April, 1856, p. 143.

* From the Lond. Chem. Gaz., No. 327.

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